roceedings of
ne United States
Jational Museum

ITHSONIAN INSTITUTION • WASHINGTON, D.C.

ume 121 1967 Number 3569

THE UNIVE
MAR 6 1967
LIBRARY

SP
1
3569

SOLDIER FLY LARVAE IN AMERICA NORTH OF MEXICO

By MAX W. McFADDEN

SMITHSONIAN PRESS

DEPOSITED BY THE
UNITED STATES OF AMERICA

Proceedings of
the United States
National Museum

SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 121 1967 Number 3569

SOLDIER FLY LARVAE IN AMERICA NORTH OF MEXICO [1]

By MAX W. MCFADDEN [2]

The Stratiomyidae or soldier flies are represented in America north of Mexico by approximately 237 species distributed through 37 genera. Prior to this study, larvae have been described for only 21 species representing 15 genera. In addition to the lack of adequate descriptions and keys, classification has seldom been attempted and a phylogenetic treatment of the larvae has never been presented.

The present study has been undertaken with several goals in mind: (1) to rear and describe as many species as possible; (2) to redescribe all previously described larvae of North American species; and (3), on the basis of larval characters, to attempt to define various taxonomic units and show phylogenetic relationships within the family and between it and other closely related familes.

Any attempt to establish subfamilial and generic limits must be regarded as tentative. This is especially true in the present study since larvae of so many species of Stratiomyidae remain unknown. Undoubtably, as more species are reared, changes will have to be made in keys and definitions of taxa.

The keys have been prepared chiefly for identification of last instar larvae. If earlier instars are known, they either have been

[1] Modified from a Ph. D. dissertation submitted to the University of Alberta, Edmonton, Canada.

[2] Entomology Research Division, U.S. Dept. Agriculture, Tobacco Insects Investigations, P.O. Box 1011, Oxford, N.C. 27565.

included in the key or a separate description has been given—or both. Because pupation takes place within the last larval skin, the puparium can be identified with the keys to the larvae.

I wish to extend sincere appreciation to Dr. George E. Ball of the University of Alberta, Edmonton, for his excellent direction of the study; to Dr. Maurice T. James of Washington State University, Pullman, for his constant help and advice on many problems; to Dr. Willis W. Wirth of the U.S. Department of Agriculture, Washington, D.C., for his advice and for reviewing the manuscript; and to the University of Alberta and the National Research Council of Canada for their financial assistance.

I also wish to acknowledge with thanks material loaned from the following entomologists and institutions (abbreviations that follow are used throughout this text):

American Museum of Natural History, New York, N.Y. (P. Wygodzinsky)—AMNH
California Academy of Sciences, San Francisco, Calif. (P. Arnaud, Jr.)—CAS
Canada Department of Agriculture, Belleville, Ont. (H. G. James)—CDA
Canadian National Museum, Ottawa, Ont. (G. E. Shewell)—CNC
Clemson College, Clemson, S. C. (R. C. Fox)—CC
Colorado State University, Fort Collins, Colo. (T. O. Thatcher)—CSU
Cornell University, Ithaca, N.Y. (C. O. Berg and H. Dietrich)—CU
Deutches Entomologisches Institut, Berlin, Germany (W. Hennig)—DEI
Illinois Natural History Survey Collection, Urbana, Ill. (L. K. Gloyd)—INHM
Louisiana State University, University Park, La. (H. V. Daly)—LSU
M. W. McFadden Collection—MWM
North Carolina State College, Raleigh, N.C. (R. L. Rabb)—NCSC
Ohio State University, Columbus, Ohio (J. G. Rozen)—OSU
Purdue University, Lafayette, Ind. (L. Chandler)—PU
Rockefeller Foundation, Mexico, D.F., Mexico (J. L. Carrillo S.)—RF
University of California, Berkely, Calif. (P. Ashlock and R. L. Usinger)—UCB
University of Delaware, Newark, Del. (P. P. Burbutis)—UD
University of Kansas, Lawrence, Kans. (W. J. Hanson)—UK
University of Maine, Orono, Maine (G. W. Simpson)—UM
University of Massachusetts, Amherst, Mass. (M. E. Smith)—UMASS
University of Michigan, Ann Arbor, Mich. (T. E. Moore)—UMICH
University of Missouri, Columbia, Mo. (W. R. Enns)—UMO
United States National Museum, Washington, D.C. (W. W. Wirth)—USNM
Washington State University, Pullman, Wash. (M. T. James)—WSU

Methods

A suitable technique for removing larvae from various substrates has been developed (McFadden, 1961). Specimens thus obtained for this study were divided into two groups: one to be reared, the other to be preserved.

Larvae were killed and preserved in 70 percent alcohol without additional treatment. In the case of large specimens, the alcohol was changed after a month's lapse.

Rearing was simplified by collecting in the spring, when larvae were usually in the last instar, about to pupate, or had already pupated. Larvae and pupae held for rearing were placed in 5-dram vials fitted with cotton stoppers. A small amount of the substrate in which the animal was found was placed in the vial before adding the specimen. Distilled water was added occasionally to maintain moist conditions. Larvae and pupae were always reared individually so that emerging adults or parasites could be associated with the respective larval or pupal skin. The adults were then identified and associated with the larvae that had not been reared, and thus the identity of these larvae was determined. This is by no means a foolproof system for identification, but in most instances it can be relied upon because of the gregarious nature of the larvae.

In observing preserved specimens, I frequently found that many morphological characters that are used in distinguishing the various taxa were obscured by deposits of calcium carbonate and environmental debris. The larvae were quickly cleaned of most of the debris by soaking them in 10 percent hydrochloric acid (Lundbeck, 1907, and Johannsen, 1935). Active effervescence always accompanied this treatment.

The head of the larva was prepared for study by removing it from the body and placing it in a test tube containing 2 percent potassium hydroxide. The tube was placed in a beaker of water and boiled slowly for 2 hours. The heads then were washed in glacial acetic acid, dissected, and mounted on a slide. Photomicrographs were prepared using the technique described by Howden (1955).

Historical Résumé

From 1720 to the present, numerous papers have been written on various aspects of stratiomyid natural history as well as on morphology and physiology of the larvae. Rather than attempt to condense a voluminous literature in a few paragraphs here, I shall discuss these works under their appropriate sections of biology, morphology, phylogeny, and classification.

Studies on the biology and systematics of larval Stratiomyidae can be divided into 2 rather distinct periods.

The first period (1720–1868) was devoted to the description of local faunas. In most instances larvae were associated with adults through rearing so that correct identifications were obtained; however, no attempts at classification were made nor were other generalities presented.

The second period, which was initiated by Brauer (1869), was characterized by the incorporation of biological features and the

characteristics of the immature stages in classification. Using Schiner's classification (1868) based on adults, Brauer demonstrated that the immature stages of Diptera could be used as a check against an already existing system of classification. Although Brauer did not organize the Stratiomyidae into its component genera, he did recognize that the Stratiomyidae, Tabanidae, Rhagionidae (Leptidae), and Coenomyidae were closely allied and placed them in the tribe Cyclocera under the Orthorrhapha-Brachycera.

Brauer (1883) once again reviewed the characters of dipterous larvae and, on the basis of differences in head capsules, established a new classification in which the Stratiomyidae and Xylophagidae were considered as separate families but were placed together in the Notacantha. In the same paper, Brauer divided the Stratiomyidae into its various genera and listed the larval characters for each genus.

Austen (1899) presented a clear and concise review of the problem regarding the classification of *Solva*, subsequent to which the majority of dipterists have considered the genus to be located in the Xylomyinae (Solvinae), a subfamily within the Stratiomyidae (for further details, see page 13).

Malloch (1917) was the first person to arrange systematically the North American Startiomyidae on the basis of larvae. As might be expected, numerous genera were omitted since many larvae had as yet not been described.

Johannsen (1922, 1935) continued the work of Malloch. He added several new descriptions of larvae and supplied much of the data on biology that we have today.

The most recent contribution to the classification of stratiomyid larvae has come from Willi Hennig. In his outstanding work "Die Larvenformen der Dipteren" (1952) the species are listed for each genus and their distribution given by zoogeographical region. In addition, he has included biological notes for nearly all the species mentioned.

Biology

The following discussion comprises a review of the literature on the biology of the Stratiomyidae along the lines of a general life history, with each study of a particular stage included under its respective heading.

Irwin-Smith (1920, 1921) was the first to achieve some success in rearing in a laboratory the complete life cycle of a species. Although she was able to obtain a cycle from larva to larva, she was unable to determine the duration of the larval stage. More recently, Furman, Young, and Catts (1959) reported that newly hatched larvae of *Hermetia illucens* require 2 weeks or longer to attain full growth

under laboratory conditions and that the pupal stage may last from 2 weeks to 5 months. May (1961), also working with *H. illucens*, gave more precise figures for the duration of the various stages in the life cycle and, in addition, was able to complete the life cycle successfully.

EGGS.—Eggs usually are laid in early spring by females that have overwintered as larvae. When first laid, the eggs are pale yellow but become progressively darker as the hatching date approaches. The actual time required for hatching varies from 5 days to 3 weeks.

Hart (1895) mentions that the eggs of *Odontomyia* are "cigar-shaped," but this is not the case throughout the family. Wesenberg-Lund (1943) reports that the eggs may be flattened or highly arched or in the form of a "regular" egg. In addition, he mentions that the eggs usually are placed in a distinct group or clump (the number varying with the species) on vegetation overhanging water, in the case of aquatic forms, or on decaying organic matter, in the case of terrestrial forms. Wesenberg-Lund (1943) also mentions that the eggs of Stratiomyidae are difficult to distinguish from those of Tabanidae.

LARVAE.—Newly hatched larvae were noted by Irwin-Smith (1921) to molt as soon as they emerged from the egg. Active feeding commenced immediately. As stated previously, the duration of the larval state is unknown but the larvae of the majority of the northern Nearctic species appear to be fully mature by fall. These mature larvae are probably the overwintering stage, as pupation does not occur until the following spring.

Larvae in each of the subfamilies exhibit a varying degree of similarity with respect to their feeding habits (James, 1960), but there is considerable variation in habitat selection by species within the subfamilies. Thus we have papers by Packard (1871), Lucas (1879), Griffith and Packard (1882), and Brues (1924, 1928, and 1932) recording the occurrence of larvae in salt water and in hot springs and lakes. Pearson (1883) reported a larva that was found on an exposed part of ocean beach, and Florentin (1899) found a great mass of larvae in excessively saline pools.

The sum of our knowledge on habitats for the larvae of the North American genera of Stratiomyidae is presented in condensed form in table 1. Except for genera such as *Actina*, which are known only from some other part of the world, the references are primarily to North American workers. It is hoped that this table will not only be an aid to collecting larvae but will also be a guide to the needs for future studies within the family. Additional information on biology of the larvae is given under the species descriptions.

PUPAE.—The stratiomyid pupa, surprisingly, is much smaller than the puparium, often being only one-third the total length of the latter.

At the onset of pupation the mature larva becomes rigid, the integument hardens, and the apical segments are usally in a distorted position. The pupa itself, enclosed in a silky cocoon secreted by the salivary glands, occupies only the anterior end of the puparium. Miall (1895) reports that earlier workers often mistook the pupa for a parasite that had devoured the larva.

Because of the shrinkage of the pupa, an air space is formed within the puparium, and thus the aquatic pupal stage becomes buoyant. As a result, the pupa floats on the surface of ponds or other bodies of water until eventually it is either blown by the wind or carried by the action of waves to the shore, where it remains with other debris until the adult emerges.

At the time of emergence the puparium splits not only along the dorsomedian line to the second abdominal segment, in the manner of the Nematocera, but also transversely on the second abdominal segment in the manner of the Cyclorrhapha.

ADULTS.—Malloch (1917) and Johannsen (1935) have stated that adult stratiomyids, of both terrestrial and aquatic forms, may be seen flying about in areas where species of Umbelliferae and Compositae are in flower or resting on vegetation that is close to water. Although there is relatively little information on feeding habits of the adults, the regularity with which they are seen on vegetation correlates with Lundbeck's observation (1907) that the adults feed on "plant juices" (nectar?).

The more commonly seen adults that represent species of *Stratiomys* and *Odontomyia* are robust in appearance and are good fliers, but there are many species in other genera that lack one or both of these attributes. Other species, especially in the genus *Sargus*, are able to hover about vegetation in the manner of a syrphid fly.

Adults may be collected by sweeping in grassy meadows, in bog areas, and in sedges, cattails, and other vegetation along the margins of streams, lakes, and ponds.

PREDATORS AND PARASITES.—Several investigators have observed parasites and/or predators attacking larvae of Stratiomyidae. In table 2, I have presented this information in condensed form and have added my own observations.

Morphology

Several notable investigations on the morphology of the Stratiomyidae have been made and have been concerned with the nervous system, the respiratory system, the head capsule, and the integument.

While the quality of this work is very good, the number of different species investigated leaves much to be desired. In this section, an attempt has been made to incorporate previous work with my own studies in a discussion of the major morphological characteristics of the larvae, both external and internal.

INTEGUMENT.—The integument of a stratiomyid larva is composed of many facets, some of which are distincly hexagonal while others vary in size and shape. This faceted appearance has caused students of Stratiomyidae to refer to the integument as being "shagreened."[3]

Many early investigators (Miall, 1895; Leydig, 1860; Müller, 1925; and Kruper, 1930) noticed the presence of these facets and explained their appearance as representing the upper surface of the "calcareous nails" that are so evident in a cross section of the integument (fig. 6). These nails are composed of calcium carbonate, but how they are formed is unknown. Earlier workers were of the opinion that the calcium deposits were secreted probably by the malpighian tubules in an unknown manner. Richards (1951), on the contrary, is of the opinion that the calcium deposits are laid down on the external surface of the integument as a result of carbon dioxide diffusing outward through the integument into the calcium-rich medium of water. His theory, however, will not explain the development of the "nails" under the acid conditions in which many species of stratiomyid larvae occur, nor will it explain the development of the "nails" in terrestrial species.

The "nails" provide the larva with a strong but flexible armor. To test its resistence to attack one needs only to try to section it. Flexibility is obtained by the pyramidal shape of the nails, which allows the integument to bend.

HEAD AND APPENDAGES.—The total length of the head is always greater than the width. This may seem misleading since the head is permanently retracted approximately one-half of its length into the thorax (fig. 3).

Distinctive eye prominences are situated on the lateral margin of the ocular lobes. Located between the 2 ocular lobes is the clypeus, which is limited by the frontal sutures. At the distal end of the clypeus is the labrum, a structure that is not always clearly defined posteriorly by the clypeolabral suture. The mandibular-maxillary complex is located in the pocket formed by the labrum and the extensions of the ocular lobes. The complex itself is formed by the fusion of the mandibles and the maxillae as the name suggests. It is so articulated that movement is in a plane perpendicular to the long

[3]Derived from the near-eastern word "shagreen," a type of uncured leather prepared in that area. As used here, it doubtless refers to the multifaceted integument that suggests this type of leather.

axis of the body. Cook (1949) states that the mandibular-maxillary complex is used for sweeping food into the oral cavity rather than for chewing.

The 2-segmented antennae are located near the apex of the ocular lobes but the exact position varies with the species as does the size and shape.

On the ventral surface of the head (fig. 4) there is a membranous area that outlines the labium. The large posterior part of the labium is the submentum. Directly anterior to the submentum is the prementum and the palatum. The latter structure, as pointed out by Cook, is apparently an adaptation for rooting up material. Cook also reported that labial palpi and a hypopharynx are lacking in stratiomyid larvae. The arrangement of the previously mentioned structures is shown in figure 5. The most important feature illustrated here is the arrangement of 2 sclerotized plates that are located beneath the pharynx at the posterior end of the head capsule. These structures function as a mortar and pestle, grinding up the food material that is swept into the mouth by the manibular-maxillary complex (Bischoff, 1925; Cook, 1949). The bowl-like mortar is very heavily sclerotized and convoluted while the pestle, which is formed by the floor of the pharynx, is modified in the form of a heavy, corrugated plate and fits into the bowl of the mortar.

If the mortar and pestle do indeed perform the task of grinding the food, it seems inconceivable that stratiomyid larvae could be predaceous on other larvae as has been reported, especially when the size of the oral cavity is taken into consideration.

THORAX.—The thorax is composed of the first 3 body segments posterior to the head. The noteworthy characteristics found here are the prothoracic spiracles, which vary in size and shape, the chaetotaxy, and the shape of the segments, which seem to become broader toward the metathoracic segment. Stratiomyid larvae are without legs or prolegs.

ABDOMEN.—This tagma consists of the 8 body segments posterior to the metathoracic segment. They are similar in form to the thoracic segments but differ in chaetotaxy and in occurrence of special organs or structures. Several genera can be distinguished by the markings or color patterns that occur on the thoracic and abdominal segments.

The first and second segments are usually the broadest. The remainder of the segments either taper toward the apical segment (aquatic species) or several segments are parallel sided and the remainder taper toward the apical segment (terrestrial species). At the extreme end of the apical segment, which is often much longer than it is wide (fig. 107), especially in the aquatic species, there is located a transverse fissure that houses the spiracular chamber. In the genus

Nemotelus, however, the spiracular chamber is located on the dorsum of this segment.

A few aquatic genera, notably *Euparyphus* and *Odontomyia*, possess strongly curved sclerotized hooks or spines, as they sometimes are called (fig. 122). They are usually on the venter of the seventh abdominal segment, but in the genus *Hedriodiscus* they are on the venter of the sixth segment as well. A remarkable feature of the spines is that they curve forward toward the head. This arrangement would seem to present some difficulty in forward movement, but this has not been observed. Previous workers (Wesenberg-Lund, 1943; Lenz, 1923) have reported that the hooks serve as anchors to keep the larvae from being swept away by fast-flowing currents. This statement may be partially correct, but I have observed this type of larva in shallow pools that had only convection currents.

DIGESTIVE SYSTEM.—The digestive system has little to offer in the way of taxonomic characters other than the characteristic shape of the gut, which is long and highly convoluted. Except for the mortar and pestle, there are no sclerotized areas present in either the foregut or the hindgut.

MALPIGHIAN TUBULES.—The malpighian tubules are filled with a whitish, semiliquid material that is reported to be primarily composed of calcium carbonate. This material may be associated in some manner with the calcium carbonate that is secreted in the integument.

RESPIRATORY SYSTEM.—Stratiomyid larvae have frequently been described as peripneustic, but it is doubtful that they are functionally so. They appear to be metapneustic or in some cases amphipneustic. The lateral spiracles almost always are minute and difficult to detect, especially in the later instars. The only spiracles that function continually are the terminal or posterior spiracles.

The spiracular chamber contains the ends of the main tracheal trunks. In the aquatic forms, the lips that form the opening to the chamber are fringed with long hydrofuge setae, which enable the larvae to remain suspended from the surface of water for indefinite periods of time while the spiracles are open to the atmosphere. When submerged, these setae also aid respiration by enclosing an air bubble trapped in the process of submerging.

Using the work of Whitten (1959) as a guide, I examined the tracheal system of 4 genera (2 aquatic and 2 terrestrial) for possible taxonomic characters. The tracheal system of each larva has the same general pattern as that given by Whitten for brachycerous larvae and, consequently, cannot be used as a distinguishing character beyond the suborder.

NERVOUS SYSTEM.—Although several studies have been made on the nervous system of a few species of stratiomyid larvae, the results

appear to have little consequence from a taxonomic standpoint (Viallanes, 1882a, 1882b, 1885; Künckel d'Herculais, 1879; Henneguy and Binet, 1892).

Phylogeny

Handlirsch (1908) postulated that the Stratiomyidae arose in Jurassic times from a primitive tipuloid stock that had evolved to the point where it more closely resembled the Xylophagidae than the Tipulidae. The families most like the Stratiomyidae, the Xylophagidae and the Rhagionidae (Leptidae), are similar to the stratiomyid subfamily Xylomyinae but only in the adult stage (wing venation, spurs on tibiae, etc.). From the Rhagionidae arose the Tabanidae and Therevidae and, in turn, this line of descent led directly to the more advanced Diptera (Handlirsch, 1908; Bischoff, 1925; and Lindner, 1937).

The most primitive subfamily in the Stratiomyidae is the Xylomyinae. Characters occuring in the immature stages of this subfamily that I consider to be primitive are an integument that is only partly shagreened, the generalized type of its mouthparts, an incompletely enclosed pupa, and the type of habitat, which is usually under bark or in rotten logs. Characters of the adults are equally primitive.

From this primitive subfamily 4 lines appear to have evolved, one of which represents a continuation of the basic type with slight modifications in morphology (Xylomyinae, Beridinae, and Pachygastrinae). The other lines represent a divergence toward different ecological zones in the larval stage: one to an aquatic or semiaquatic mode of life (Stratiomyinae and Nemotelinae); another to life in a rich, soft food source such as animal excrement and decaying organic matter (Sarginae and Clitellariinae); and another line, represented by *Altermetoponia rubriceps* (Macquart), which lives in sod (Chiromyzinae).

As previously indicated, the environment in which the larvae live, their feeding habits, and the type of mouthparts are closely allied and provide an insight into the evolution of the family. Table 3 illustrates the distribution of these characters through the subfamilies. In an attempt to show degree of relationship, I have analyzed 11 characters and given them an arbitrary numerical value (for details of this technique, see James, 1953). A list of the characters and their numerical values is as follows:

A. Habitat of larva
   1. aquatic or semiaquatic
   2. terrestrial
   3. terrestrial-arboreal (close association with trees)

B. Food of larva
   1. aquatic microorganisms
   2. plant roots
   3. decaying organic matter (includes microorganisms)
C. Labium of larva
   1. well developed
   2. not well developed
D. Distribution of maxillary setae in larva
   1. setae absent
   2. setae present, located in notch
   3. setae present, other arrangement
E. Types of maxillary setae in larva
   1. cylindrical brushes
   2. cylindrical brushes absent or not cylindrical
F. Transverse series of dorsal setae with accompanying setae in larva
   1. extra setae present
   2. extra setae absent
G. Posterior spiracles of larva
   1. with coronet of setae
   2. without coronet of setae
H. Anal armament of larva
   1. large teeth anterior to anal opening
   2. large teeth absent
I. Body conformation of larva
   1. attenuate
   2. parallel sided
J. Mandibles of larva
   1. well developed
   2. not well developed
K. Posterior spiracles of larva
   1. located at apex of last abdominal segment
   2. located on dorsum of last abdominal segment

These results are presented in graph form in figure 1. The phylogenetic tree in figure 2 represents the sum of the similarities and differences among the subfamilies and indicates the relationships of the extant species.

The Beridinae and succeeding subfamilies of the Stratiomyidae probably arose from a group of the subfamily Xylomyinae that had developed a completely shagreened integument. This separation was no doubt strengthened subsequently by 2 changes in the ecological requirements of beridine larvae: a change in habitat (larvae of Beridinae are not found in the same habitat as larvae of Xylomyinae) and a change in food preference (as evidenced by larvae of *Actina incisuralis*).

The subfamily Pachygastrinae represents an advanced group on the basis of adult characters, but the mouthparts of the larvae are

similar to those found in the larvae of Xylomyinae and Beridinae. In addition, pachygastrine larvae are found under the bark of trees as are larvae of Xylomyinae. During the course of time, however, the chaetotaxy and size of the larvae have evolved.

On the basis of similarity of mouthparts, the Clitellariinae and the Pachygastrinae appear to have arisen from a beridine stock. The former represents a radiation into a new ecological zone, and the latter represents evolutionary improvement for living in an already occupied niche. Clitellariine larvae have mouthparts much the same as beridine larvae except for the labium, which has become more sclerotized and spatulate in the former. This change in the labium is probably an adaptation for feeding on the pulpy flesh of succulents.

The Sarginae appear to have arisen from a clitellariine stock, probably closely related to the tribe Hermetiini. The mouthparts of the latter are very similar to those of the Sarginae and both groups live in the same type of enviroment—decaying organic material. Both groups are highly evolved: the mouthparts have degenerated so that the mandibular-maxillary complex is almost indistinguishable.

The subfamily Nemotelinae, although similar in general appearance to the Stratiomyinae, apparently has evolved from a clitellariine stock. This cleavage, however, must have occurred shortly after the Clittellariinae had broken away from the pachygastrine stem since all three taxa are closely related (fig. 2). Both adult and larval characters of the Nemotelinae appear to substantiate the conclusion that the Stratiomyinae and Nemotelinae are not closely related and probably never have been.

The Stratiomyinae have few characters in common with any of the extant subfamilies. Larval characters indicate that the subfamily probably evolved from a beridine stock at a very early period.

Because the Chiromyzinae are represented in North America by only *Altermetoponia rubriceps*—an introduced species—no further consideration need be given to the phylogeny of this subfamily.

Classification

The classification of the Stratiomyidae presented here is based upon opinions and conclusions drawn from the relationships of the subfamilies presented in the previous section. This system differs somewhat from the classification of James (pers. comm.), which is based upon adult characters. A comparison of the 2 systems is as follows (asterisks indicate genera not seen in immature stages and thus not in my classification):

James	McFadden
1.	1. Xylomyinae—*Xylomya, Solva*
2. Chiromyzinae—*Altermetoponia*	2. Chiromyzinae—as in James
3. Beridinae—*Allognosta, Actina, Beris, Exodontha*	3. Beridinae—as in James
4. Sarginae—*Sargus, Ptecticus, Microchrysa, Chloromyia,* Merosargus*	4. Sarginae—as in James
5. Cyphomyiinae—*Cyphomyia, Dicyphoma*	5. Cyphomyiinae—see under Clitellariinae
6. Hermetiinae—*Hermetia*	6. Hermetiinae—see under Clitellariinae
7. Clitellariinae—*Adozomyia, Dieuryneura, Brachycara,* Euryneura,* Oxycera,* Euparyphus, Caloparyphus, Akronia,* Nemotelus*	7. Clitellariinae—*Dieuryneura* Cyphomyiini—*Cyphomyia, Adozomyia, Dicyphoma* Hermetiini—*Hermetia*
8. Stratiomyinae—*Stratiomys, Hoplitomyia,* Labostigmina,* Anoplodonta,* Hedriodiscus, Odontomyia, Nothomyia,* Myxosargus*	8. Stratiomyinae—*Stratiomys, Hedriodiscus, Odontomyia, Myxosargus, Euparyphus, Caloparyphus, Aochletus*
9.	9. Nemotelinae—*Nemotelus*
10. Pachygastrinae—*Neopachygaster, Eupachygaster, Pachygaster, Zabrachia, Berkshiria*	10. Pachygastrinae—as in James

There are 2 major points of difference between the present arrangement and that of James. First, the latter includes the genera *Xylomya* and *Solva* in a separate family, the Xylomyidae. Although there is little information in the literature regarding the larva of *Xylomya*, many workers have recorded their thoughts on the larva of *Solva* and its importance in classification; thus, we have papers by Westwood (1840), Osten Sacken (1882), Brauer (1883), Lindner (1937), and Hennig (1952) pointing out that *Solva* should be placed in the Stratiomyidae. In 1899 Austen presented a summation of previous work concerning the classification of *Solva* and came to the conclusion "that *Solva* represents a primitive ancestral form of Stratiomyidae, given off from the common stem after the evolution of the characteristic type of larva and mode of pupation, but before the assumption on the part of the imago of the equally characteristic features (venation, spurless tibiae, etc.) exhibited by the more specialized types of the family." Inasmuch as the larvae of *Xylomya* and *Solva* are almost indistinguishable morphologically, I have extended Austen's discussion to include *Xylomya* and have reorganized the subfamily Xylomyinae.

A second area of disagreement between the 2 systems is in the classification of the Clitellariinae. A study of the mouthparts revealed that there were 3 distinct types present in this 1 subfamily.

One type was found in the genus *Adoxomyia*. The mouthparts of the species in this genus are very similar to those found in the larva of *Cyphomyia*. In addition, the larvae of both genera are known only from wounded or decaying succulents in North America; consequently, *Cyphomyia* and *Dicyphoma* have been transferred to the Clitellariini (Cyphomyinae of James) along with *Adoxomyia*.

A second tribe, the Hermetiini (Hermetiinae of James), has been transferred to this subfamily on the basis of similarities in morphological and ecological characters of both adults and larvae of *Hermetia* to the clitellariine genera *Adoxomyia*, *Cyphomyia*, and *Dicyphoma*.

The genus *Dieuryneura* has been placed in this subfamily also but not in either tribe. A comparison of larval mouthparts shows it to be more closely related to the Hermetiini than to the Clitellariini, but a more definite attempt at classification is impossible at this time.

The larvae of the remaining genera in the Clitellariinae of James are either aquatic or semiaquatic and the mouthparts are similar to the genera originally placed in the Stratiomyinae. These 2 facts by themselves give sufficient cause to unite the genera in a single subfamily; in addition, all of the genera except *Nemotelus* that were removed from the Clitellariinae possess ventral hooks. These curious structures may represent a clinging device for living in fast-flowing water. *Stratiomys* larvae lack these structures but they are present on larvae of *Odontomyia*. It is possible that the hooks have evolved twice but it seems more likely that the genera are more closely related than they were previously thought to be.

Larvae of *Nemotelus* pose a special problem. In addition to lacking the ventral hooks, the orifice of the spiracular chamber is on the dorsal surface of the last abdominal segment and possesses a cornet of hydrofuge setae as contrasted with the terrestrial larvae that lack this feature and as contrasted with other aquatic larvae that also possess a coronet of hydrofuge setae but have the spiracular chamber at the apex of the last segment. This combination of characters is rather unique and provides the basis for elevating this genus to subfamilial status.

Key to Suborders, Divisions, and Principal Families of Brachycera-Orthorrhapha Based on Larval Characters

1. Head complete, or the posterior portion with deep longitudinal incisions; mandibles capable of horizontal movement; body consisting of 13 segments in addition to head; with 9 pairs of spiracles . . Suborder NEMATOCERA

   Head incomplete, frontal region not strongly arched; mandibles capable of vertical movement; body comprising fewer than 13 segments and only exceptionally with as many as 9 pairs of spiracles.

   Suborder BRACHYCERA 2

2. Free cephaloskeleton present; head very poorly developed, completely unsclerotized dorsally; antennae poorly developed or absent, when present situated on a membranous surface; mandibles short and hooklike, usually capable of protrusion much beyond the poorly developed maxillae; maxillary palpi rarely visible . . . . . Division CYCLORRHAPHA

No free cephaloskeleton within the head capsule, the exoskeleton of the head at least dorsally indicated; antennae well developed, situated on the upper surface of the lateral lobe or on the slightly arched, sclerotized frontal plate; mandibles normally sickle shaped, not protruding much beyond apices of the well-developed maxillae, often much shorter, maxillary palpi distinct. Division ORTHORRHAPHA 3

3. Posterior spiracles situated within a terminal or subterminal cleft or chamber, usually concealed, or with a terminal breathing tube; pupa free or enclosed in last larval skin 4

Posterior spiracles visible, situated on apical, penultimate or antepenultimate segment, body not shagreened or visibly striated; pupa free 5

4. Body 12-segmented, cylindrical, not shagreened, usually longitudinally striated, abdomen with a girdle of pseudopods on each segment; head retractile; spiracular fissure vertical . . . . . TABANIDAE

Body 11-segmented, bristly, surface finely shagreened, without pseudopods; head not retractile; spiracular fissure transverse, sometimes rather small; peripneustic or amphipneustic . . . . . STRATIOMYIDAE

5. Posterior spiracles situated on penultimate or antepenultimate segment. THEREVIDAE, SCENOPINIDAE, MYDAIDAE, ASILIDAE, BOMBYLIIDAE

Posterior spiracles situated on apical segment 6

6. Last abdominal segment obliquely truncate and with projecting processes; projecting portion of head and the flattened apical plate of last abdominal segment heavily sclerotized, the former cone shaped . . XYLOPHAGIDAE (including Rhachiceridae and Coenomyidae)

Last abdominal segment lacking projecting processes; projecting portion of head not pointed cone shaped; last abdominal segment without a heavily sclerotized flattened terminal plate . . . . . NEMESTRINIDAE, EMPIDIDAE, DOLICHOPODIDAE, RHAGIONIDAE, ACROCERIDAE.

Family Stratiomyidae

In addition to the characters given in the key to families, stratiomyid larvae may be readily distinguished from other dipterous larvae (except for psychodid larvae) by the presence of calcium carbonate deposits on the integument (see p. 7).

FAMILY DIAGNOSIS.—Head elongate and narrow except for ocular prominences; not retractile; antennae usually located anterolaterally but varying among species; setae on dorsum of head variable; body 11-segmented; prothoracic segment with functional spiracles, that segment wider than the head; segment posterior to prothorax either parallel with the lateral margins of the prothorax or tapering in a posterior direction from the second abdominal segment as in *Stratiomys* (fig. 105); posterior spiracles located in a transverse cleft on last abdominal segment; with or without a fringe of hydrofuge setae;

pseudopods lacking, but strong curved hooks may be present on venter of penultimate and/or antepenultimate segment.

Key to Larvae of Subfamilies of Stratiomyidae of America North of Mexico

1. Last abdominal segment with a coronet of plumose or pinnate setae at the apex . . . . . STRATIOMYINAE
   Last abdominal segment with coronet of plumose or pinnate setae absent from apex 2
2. Last abdominal segment with a coronet of plumose or pinnate setae on dorsum . . . . . NEMOTELINAE
   Last abdominal segment lacking a coronet of plumose or pinnate setae . . 3
3. Pro- and mesothoracic segments with a smooth field on dorsum; anus bordered anteriorly by a transverse row of strong, posteriorly directed teeth. XYLOMYINAE
   Pro- and mesothoracic segments with normal shagreened pattern on dorsum; anus not bordered anteriorly by teeth 4
4. Mouthparts highly sclerotized and foreshortened, mandibles well developed, no setae or bristles present on mouthparts (fig. 15); recorded from San Francisco area only . . . . . CHIROMYZINAE
   Mouthparts with a different combination of characters than those listed above; occurring in San Francisco area or elsewhere 5
5. Dorsal row of transverse setae surrounded by smaller setae; mouthparts as in figure 16; uniformly colored larvae . . . . . BERIDINAE
   Dorsal row of transverse setae not surrounded by smaller setae; mouthparts different than above; larvae uniformly colored or with a pattern 5
6. Larva with a well-developed labium (fig. 19); primarily restricted to southwestern United States, where found in *Opuntia* or *Agave* species. CLITELLARIINAE, Tribe CLITELLARIINI
   Larva lacking a well-developed labium; occurring in southwestern United States and elsewhere; not recorded from hosts given above 7
7. Small larva, under 10 mm in length; mouthparts similar to those of Beridinae (fig. 18); found under bark of trees . . . . . PACHYGASTRINAE
   Larva over 10 mm in length; mouthparts lacking sclerotized areas 8
8. Mouthparts simple, setae restricted to a linear patch on inner margin of mandibular-maxillary complex (fig. 21); large, robust, color uniform. CLITELLARIINAE, Tribe HERMETIINI
   Mouthparts more elaborate, setae present on mandibular-maxillary complex, in addition to setae restricted to notch on inner margin of complex (fig. 17); smaller, usually with a vittate pattern . . . . . SARGINAE

Subfamily Xylomyinae

This subfamily is represented in North America by the 2 genera *Xylomya* Rondani and *Solva* Walker. It is considered the most primitive group of the Stratiomyidae because it shares at least 1 character of the adult stage with the corresponding stage of the generally more primitive Xylophagidae.

SUBFAMILIAL CHARACTERS.—Mouthparts as in figure 14. Other characters as given in key to subfamilies.

HABITAT OF LARVAE.—The few records available indicate that the larvae live under the bark of trees and in rotting logs.

Key to Genera of Xylomyinae

Prothoracic segment of larva with a tubercle anterior to the spiracle giving a cleft appearance to margin (fig. 10); apical abdominal segment with a transverse row of tubercles on dorsum . . . . . **Solva** Walker

Prothoracic segment of larva lacking cleft appearance of margin; no tubercles present on dorsum of apical abdominal segment . . . . . **Xylomya** Rondani

Genus *Xylomya* Rondani, 1861

Of the 7 species listed by James (pers. comm.) for this genus, the larvae of only 2 species have been collected and 1 lacks a specific determination.

GENERIC CHARACTERS.—As given in key to genera.

Xylomya americana (Wiedemann), 1821

FIGURES 149, 150

DESCRIPTION.—Puparium: length (head capsule lacking) 15.2 mm; width 4.1 mm. Other characters as given in key to genera.

BIOLOGY.—Larvae of this species were removed from a hole in a sycamore tree.

MATERIAL EXAMINED.—Virginia: Alexandria, Oct. 14, 1951, W. W. Wirth, 1 puparium (USNM).

Xylomya species

FIGURES 7, 11, 25

DESCRIPTION.—Mature larva: length 13 mm; width 3.2 mm. Other characters as given in key to genera.

BIOLOGY.—No data available for this species.

MATERIAL EXAMINED.—Massachusetts: Amherst, 1945, M.E.S., 1 larva, MSC.

Genus *Solva* Walker, 1860

James (pers. comm.) lists 3 species for this genus but the larva of only 1 species, *Solva pallipes* (Loew), has been collected.

Lindner (1938) and Hennig (1952) include the species of *Xylomya* in this genus, but Steyskal (1947) has demonstrated that the adults of these 2 genera can be distinguished. This shows that the immature stages can also be differentiated.

GENERIC CHARACTERS.—As given in key to genera.

Solva pallipes (Loew), 1863

FIGURES 8–10, 12–14

DESCRIPTION.—Mature larva: length 7–8 mm, mean 7.8 mm; width 1.75–2.0 mm, mean 1.85 mm. Other characters as given in key to species.

Pupa (after Greene, 1926): Very thin, shining, transparent, with a yellowish tinge. Antennal capsules large, pointing outward, faintly annulated to the tip; just posterior to the base of these are 3 faint ocellar punctures. Thorax slightly longer than wide, smooth; wing pads smooth, reaching to the apex of the third abdominal segment; thoracic spiracles situated on a small elevation; the spiracular entrance is golden yellow, sinuous, and contains a great number of short radiating slits. Abdomen cylindrical, composed of 8 segments; first and last segment without any spines; segments 2–7 with a transverse, dorsal row of reddish-yellow spines just posterior to the middle of the segment; segments 1–7 have a spiracle on the antero-lateral surface; spiracle small, golden yellow, slightly elevated; last segment rounded at apex and entirely smooth. Length 6.0 mm; diameter of thorax 1.85 mm; diameter of abdomen 1.75 mm.

BIOLOGY.—Larvae have been collected from the following trees: *Ulmus* species, *Populus* species, *Robinia* species, and *Liriodendron tulipifera*. The larvae seem to prefer trees on which the bark has become loosened. Malloch (1917) intimates that he found the larva of *Solva* to be predaceous on the larvae of *Euxesta*, *Lonchaea*, and *Heterominga*. Greene (1926) states that the larvae may be predaceous but are usually scavengers.

As the larva of *Solva* matures, it forms a pupa within the last larval skin as is the case with all other stratiomyid larvae; however, before emergence, the puparium splits dorsally down the median line and the pupa forces itself about two-thirds of the way out of the puparium and remains there until the adult emerges. The emergence of the pupa causes the head of the puparium to become loose and often completely separated as in the higher flies. Adults of *Solva* can be found on tree trunks in June, July, and August.

MATERIAL EXAMINED.—Illinois: Rock Island, Apr. 5, 1932, C. O. Mohr, 2 larvae, INHM. Pennsylvania: Blain, Aug. 6, 1955, F. Craighead, lot no. 55 11825, 6 larvae, 7 puparia from oak, USNM. Wisconsin: Madison, July 1938, Dodge, 23 larvae, 6 puparia from under elm bark, OSU.

Subfamily Chiromyzinae

Although the genus *Altermetoponia* Miller has been placed in this subfamily, there is some doubt as to whether it should be left here or placed in a subfamily of its own as Hennig (1952) has done. Because of a scarcity of specimens in related genera within the subfamily, it has been impossible to make a comparison of characters. Raff (1931) has provided a vague description of the larva of *Chiromyza*

australis Macquart, the only published information available on the larvae of this subfamily.

The subfamily is represented in North America only by *Altermetoponia rubriceps* (Macquart).

SUBFAMILIAL CHARACTERS.—As given in key to subfamilies.

HABITAT OF LARVAE.—The only species of Chiromyzinae for which habitat data are available is *A. rubriceps*.

Genus *Altermetoponia* Miller, 1945

FIGURES 15, 25, 33, 34

DESCRIPTION.—Mature larva: length 8.8–9.8 mm, mean 9.27 mm; width 1.8–2.0 mm, mean 1.87 mm. Body segments yellow; head brown, darkest at apex.

BIOLOGY.—It is quite probable that this species will assume economic importance in the area around San Francisco, just as it has come to be considered a pest in Australia, where it causes extensive damage to lawns. Other than evidence it lives in sod as a larva, nothing is known about its life history in North America.

MATERIAL EXAMINED.—California: San Francisco, Mission Park, Nov. 20, 1959, T. R. Haig, 35 larvae, 3 puparia, CAS.

Subfamily Beridinae

Of the 5 genera that represent this subfamily in North America, the larvae of only 2 are known: *Allognosta* and *Exodontha;* however, larvae of 2 of the remaining genera are known from other geographical areas and descriptions of these species have been included.

SUBFAMILIAL CHARACTERS.—As given in the key to subfamilies.

HABITAT OF LARVAE.—The larvae in this subfamily are terrestrial but may be associated with semiaquatic environments; e.g., Fuller (1934) found larvae of *Actina* in and on the carcass of a dead sheep, Johannsen (1922) reported larvae of *Allognosta* from decaying organic material, and the larvae of *Beris* have been found in decaying leaves. In addition to being the center of the larvae's food source, the semiaquatic medium facilitates their movement and ingestion.

Key to Genera of Beridinae

1. Larva robust, greater than 10 mm in length . . . . . **Exodontha** Rondani
   Larva smaller, less than 10 mm in length 2
2. Abdominal segments with lateral margin bilobed, the anterior smaller than the posterior one . . . . . **Allognosta** Osten Sacken
   Abdominal segments with lateral margin smooth 3
3. Last abdominal segment broadly indented at distal end and fringed with fine setae . . . . . **Beris** Latreille
   Last abdominal segment not indented at distal end; fringe lacking **Actina** Meigen

Genus *Allognosta* Osten Sacken, 1883

There are 4 species recognized in this genus, but only the larva of *Allognosta fuscitarsis* (Say) has been reported (Johannsen, 1922).

GENERIC CHARACTERS.—As given in the key to genera.

Allognosta fuscitarsis (Say), 1823

FIGURES 31, 36–38

DESCRIPTION.—Mature larva: length 9.5 mm; width 3.5 mm. Prothoracic spiracle located in a distinct marginal notch. Other characters as given in key to genera.

BIOLOGY.—Little is known of the biology and life history of this species. Malloch's (1917) specimen was obtained from woods near Urbana, Ill., while Johannsen's report (1922) stated that his specimens were found in decaying organic matter.

MATERIAL EXAMINED.—Rhode Island: Kingston, Aug. 20, 1942, H. Knutson, 1 early instar larva from glass of milk, MSC. New York: Ithaca, C. Hamilton, 2 larvae, 1 puparium, CU; Ithaca, 2 early instar larvae collected with larvae of *Fannia* species, CU. North Carolina: Great Smoky Mountain National Park, Oct. 4, 1951, J. S. Ayars, acc. no. 49768, 11 larvae, NCS.

Genus *Actina* Meigen, 1804

Only 1 species of this genus is known from North America, the immature stages of which have never been reported.

The characteristics that are given below are taken from a paper by Fuller (1934) in which she described the immature stages of an Australian species, *Actina incisuralis* Macquart.

GENERIC CHARACTERS.—As given in key to genera.

Actina incisuralis Macquart, 1847

FIGURES 40, 41, 45

DESCRIPTION.—Mature larva (?): length 9 mm. Color varying between greyish brown and brown.

Head elongated, narrow and pointed. Body strongly constricted between the segments giving the larva a scalloped appearance along the sides. Dorso-laterally the integument between each abdominal segment, and between the third thoracic and first abdominal, is produced into a small papilla projecting outwards. The thoracic segments become broader passing from the head, the abdominal segments are of uniform width and length, with the exception of the eighth, which is narrower and longer than the others, more flattened and produced into two blunt projections at the posterior corners (Fuller, 1934, p. 191).

Setal arrangement typical for family and subfamily.

BIOLOGY.—Fuller (1934) reported that larvae of this species "were found in abundance on the undersurface of a sheep carcass" and "on

the earth under masses of rotting grass" (p. 190). Larvae were also present in soil among the roots and stems of growing grasses. Pupae were obtained 7–8 months after the larvae were collected.

MATERIAL EXAMINED.—No larvae of this species were examined.

Genus *Beris* Latreille, 1802

Three species are recorded for this genus in North America but the larvae or pupae have never been reported. The larval stages of a few European species of *Beris* have been described (Lenz, 1923). The larva described below was loaned to me by W. Hennig.

GENERIC CHARACTERS.—As given in key to genera.

Beris vallata Forster, 1771

FIGURES 23, 26, 28

DESCRIPTION.—Mature larva (?): length 7–8 mm; width 2 mm. Head and body segments yellow; body of larva extremely flattened dorsoventrally; prothoracic spiracle elevated but relatively inconspicuous; body segments from second thoracic to seventh abdominal with a distinct papilla at intersegmental fold.

BIOLOGY.—Nothing is known about the biology of the North American species. Lenz (1923) reports that larvae of *Beris vallata* and 2 other species of this genus were found under the bark of a fallen tree, which was lying in a marshy area between fallen leaves (presumably wet) and at the margins of springs.

MATERIAL EXAMINED.—Two larvae borrowed from the Deutsches Entomologisches Institut; no collecting data.

Genus *Exodontha* Rondani, 1856

According to James (pers. comm.), 2 species occur in North America, but larvae and pupae of only *Exodontha luteipes* (Williston) have been found.

GENERIC CHARACTERS.—As given in key to genera.

Exodontha luteipes (Williston), 1885

FIGURES 29, 30, 35

DESCRIPTION.—Mature larva: length 11.7–15+ mm, mean 13.23 mm; width 3.8–4.5 mm, mean 4.77 mm. Head and body segments pale yellow.

BIOLOGY.—Larvae of this species were found in moist rotting wood under large boulders on a mountainside at an elevation of approximately 6000 feet. Adults emerged on June 27, 1960, in the laboratory.

MATERIAL EXAMINED.—Alberta: Banff National Park, Mt. Ishbel, June 13, 1960, Ball, Madge and McFadden, 1 larva, 4 puparia MWM.

Subfamily Sarginae

Of the 6 genera listed for this subfamily by James (pers. comm.), larvae have been described for only the following 4 genera: *Sargus*, *Ptecticus*, *Microchrysa*, and *Merosargus*.

The keys to the genera of this subfamily will work for mature larvae only, but, where earlier instars are known, descriptions of these forms are included.

SUBFAMILIAL CHARACTERS.—As given in key to subfamilies.

HABITAT OF LARVAE.—Larvae of the Sarginae are terrestrial scavengers. They have been collected from various types of manures, rotting vegetation—especially garden refuse—and from other types of decaying organic matter.

Key to Genera of Sarginae

1. Venter of sixth abdominal segment with sternal patch extending almost the length of that segment; venter of fifth abdominal segment with a smaller sternal patch (fig. 50) . . . . . **Ptecticus** Loew
   Venter of sixth abdominal segment with a shorter sternal patch; sternal patch lacking on venter of fifth abdominal segment 2
2. Dorsolateral margin of segments 1–10 with a series of large, dark plaques arranged in a circular pattern; segments 1–3 with a transverse band of these plaques connecting the 2 lateral circles; 5 vittae on dorsum, the mesal vitta much broader than the others . . . . **Sargus (Pedicellina)** James
   Dorsolateral margin of segments 1–10 lacking markings described above . . 3
3. Lateral margin of head lacking a protruding tubercle; no constriction of head posterior to eye prominence . . . **Sargus** Fabricius (sensu stricto, in part)
   Lateral margin of head with a protruding tubercle; head constricted posterior to tubercle 4
4. Eye prominence anterior to protruding lateral tubercle . **Merosargus** Loew
   Eye prominence on protruding lateral tubercle 5
5. Width of head at tubercle not more than 0.5 mm . . . **Microchrysa** Loew
   Width of head at tubercle 0.8–1.0 mm.
   Sargus Fabricius (sensu stricto, in part)

Genus *Sargus* Fabricius, 1798

Larvae of this genus are almost impossible to identify to species unless they are fully mature specimens. Earlier instars lack the characteristic patterns of the species and the head capsule apparently varies from instar to instar.

GENERIC CHARACTERS.—As given in key to genera.

Subgenus *Pedicellina* James, 1952

Sargus (Pedicellina) lucens Loew, 1866

FIGURES 49, 56, 61

DESCRIPTION.—Mature larva: length 9.2–11 mm, mean 10.1 mm; width 2.5–3.3 mm, mean 2.85 mm. Other characters as given in key to genera.

BIOLOGY.—Larvae of this species have been collected from leaf axils of cattails only where the axils were above the waterline.

MATERIAL EXAMINED.—New York: Ithaca, Apr. 8, 1921, P. W. Claasen and O. A. Johannsen, 5 larvae, 15 puparia collected from leaf axils of cattails, CU; Ithaca, July (?), 2 larvae from leaf axils of cattails, CU.

Subgenus *Sargus* Fabricius, 1798

Key to Species of Subgenus *Sargus*

1. Body segments lacking vittae; prothoracic spiracle on stalk like structure. **elegans** Loew
   Body segments with alternating dark and light vittae; prothoracic spiracle sessile 2
2. Dorsal surface of body segments with 3 dark vittae . . . . **decorus** Say
   Dorsal surface of body segments with more than 3 dark vittae 3
3. Median light band between inner 2 dark vittae parallel sided. **bipunctatus** Scopoli
   Median light band between inner 2 vittae geniculate; each of inner pair of setae located in a dark patch in median light band . . . . . **viridis** Say

Sargus (Sargus) elegans Loew, 1866

FIGURES 52, 53, 61

DESCRIPTION.—Mature larva: length 7.8 mm, width 2.4 mm; head not restricted posterior to eye prominence, ratio of width of head at eye prominence to width at neck 1.0. Other characters as given in keys to genera and subgenera.

Instar no. ?: length 4.5–5.2 mm, mean 4.96 mm; width 1.4–2.0 mm, mean 1.68 mm; differ from mature larvae since they lack the stalked prothoracic spiracle.

BIOLOGY.—Larvae of this species have been collected only from under horse manure.

MATERIAL EXAMINED.—Ontario: Marmora, June 19, 1952, J. R. Vockeroth, 2 puparia, larvae collected from under horse dung in woods, CNC. Virginia: Alexandria, June 24, 1951, W. W. Wirth, 15 larvae (early instar), from under horse dung, USNM.

Sargus (Sargus) decorus Say, 1824

FIGURES 55, 58, 59

DESCRIPTION.—Mature larva: length 4.0–4.2 mm, mean 4.1 mm; width 3.0–3.3 mm, mean 3.13 mm; width of head at eye prominence 0.81–0.94 mm, mean 0.87; width of head at neck 0.48–0.59 mm, mean 0.52 mm, mean ratio of width of head at eye prominence to width at neck 1.67. Other characters as given in key to species.

BIOLOGY.—Larvae of this species have been collected from rotting leaves and cow manure.

MATERIAL EXAMINED.—Saskatchewan: Saskatoon, Aug. 1, 1949, A. R. Brooks, 14 puparia from cow manure, CNC. Washington: Seattle, Sept. 15, 1942, lot no. 42–11571, det. by C. T. Greene, 4 larvae, 5 puparia from rotting leaves, USNM.

Sargus (*Sargus*) *bipunctatus* Scopoli, 1763

FIGURES 48, 54, 57

DESCRIPTION.—Mature larvae: length 9 mm; width 3 mm. Other characters as given in key to species.

Instar no. ?: length 6.5 mm; width 2.4 mm. Differs from mature larva since it lacks the vittae.

BIOLOGY.—Larvae of this species have been collected from cow manure. Malloch (1917) reported the larvae as being very sluggish.

MATERIAL EXAMINED.—Maryland: Braddock Heights, Oct. 1, 1921, A. N. Caudell Collection, 1 larva (early instar), USNM.

DISCUSSION.—All data regarding description of the mature larva and notes on its biology have been taken from Malloch.

Sargus (*Sargus*) *cuprarius* (Linnaeus), 1758

FIGURES 17, 62–64

DESCRIPTION.—Instar no. ?: length 6.5–7.4 mm, mean 7.04 mm; width 1.7–2.0 mm, mean 1.84 mm. Similar to *S. decorus* in this stage but much smaller.

BIOLOGY.—Larvae of this species have been collected from under cow manure.

MATERIAL EXAMINED.—Nebraska: Dunbar, Sept. 13, 1950, W. W. Wirth, 39 larvae from cow manure (early instars), USNM.

Genus *Ptecticus* Loew, 1855

Of the two species listed by James (1960) for this genus, only the larvae of *P. trivittatus* Say have been collected north of Mexico.

GENERIC CHARACTERS.—As given in key to genera.

Ptecticus trivittatus (Say), 1829

FIGURES 43, 47, 50, 51

DESCRIPTION.—Mature larva: length 11.2–13.2 mm, mean 12.68 mm; width 3.5–3.9 mm, mean 3.76 mm; apical segment with 2 setae at each corner of spiracular opening; no anal spines present; other characters as given in key to species.

Antepenultimate instar: length 12.2–15.1 mm, mean 13.67 mm; width 3.0–4.5 mm, mean 3.67 mm; larvae testaceous, no visible pattern; body setae short, partially hidden by fine pubescence that covers body; anal spines present.

BIOLOGY.—Larvae of this species have been collected from a corn compost pile, from decaying tomatoes, decaying garbage, rotting paper, decaying fruit, and from watermelon rinds. Larvae have also been collected from a fungus (*Laetiporus speciosus*).

MATERIAL EXAMINED.—Georgia: Silver Lake, Bradley, 7 larvae from decaying garbage and rotting paper, CU. Illinois: Urbana, Aug. 3, 1942, H. H. Ross, 14 larvae, INHS. Maryland: Cabin John Bridge, July 31, 1913, Barber and Shannon, 11 larvae from fungus (*Laetiporus speciosus*), USNM. North Carolina: Faison, Aug. 25, 1950, P. O. Richter, 5 larvae from watermelon, NCS; Faison, Oct. 14, 1952, Dogger and Howden, 1 larva from decaying vegetables, NCS; McCulley's, Jan. 20, 1951, Weisman, 3 larvae from watermelon rinds, NCS. Ohio: O.A.E.S., dump, Aug. 22, 1943, 17 larvae from decaying tomatoes, OSU.

***Ptecticus sackenii* Williston, 1885**

DESCRIPTION.—Mature larva: length 11 mm; width 4.5 mm.

BIOLOGY.—No data available.

MATERIAL EXAMINED.—Mexico: No other data, 2 larvae collected by A. Herrana, AMNH.

DISCUSSION.—According to W. W. Wirth of the U.S. Department of Agriculture, this species does not occur in Mexico. The 2 larvae examined by the author were indistinguishable from the antepenultimate instar of *P. trivittatus*. The identification is made less creditable by the fact that both larvae were neither reared nor associated with adult flies in the collection.

Genus *Microchrysa* Loew, 1855

James (pers. comm.) lists 2 species for this genus but only the larvae of *Microchrysa polita* (Linnaeus) have been collected to date.

GENERIC CHARACTERS.—As given in key to genera.

***Microchrysa polita* (Linnaeus), 1758**

FIGURES 42, 44, 46

DESCRIPTION.—Mature larva: length 5.2–7.1 mm, mean 6.68 mm; width 1.6–2.0 mm, mean 1.84 mm; width of head at eye prominence 0.45–0.50 mm, mean 0.47 mm; width of head at neck 0.32–0.42 mm, mean 0.36 mm; mean ratio of width of head at eye prominence to width at neck 1.32; venter of sixth abdominal segment with the setae on each side of the sternal patch reduced; anal spines lacking.

BIOLOGY.—Larvae of this species have been collected from cow manure and from decaying vegetation.

MATERIAL EXAMINED.—Colorado: Woodland Park, Station 4, Aug. 4, 1943, J.A.R. and H. H. Ross, 3 larvae from cattle droppings, UC. Massachusetts: Amherst, July 10, 1942, M. E. Smith, 15 larvae, 2

puparia from decaying vegetation, MSC. New York: Ithaca, July 8, 1915, 4 larvae from cow manure, CU; Ithaca, July 1917, 5 larvae, 3 puparia from decaying rhubarb, CU; Ithaca, July 1919, 9 larvae, CU. North Carolina: Rowan County, Dec. 14, 1955, C. E. Jernigan, 1 larva from woods trash, NCS.

Genus *Merosargus* Loew, 1855

Of the 2 species listed by James (pers. comm.) for this genus, only the larvae of *Merosargus caerulifrons* (Johnson) have been collected to date.

GENERIC CHARACTERS.—As given in key to genera.

Merosargus caerulifrons (Johnson), 1900

FIGURE 151

DESCRIPTION.—Puparium: length 5.6 mm (head capsule and prothorax lacking); width 2.3 mm; head capsule similar to that of *Sargus lucens* but differing in key characters.

BIOLOGY.—A puparium of this species was collected from debris at the base of a squirrel's nest.

MATERIAL EXAMINED.—Maryland: Linnieville, Jan. 1, 1914, R. C. Shannon, 1 puparium with head capsule detached, USNM.

Subfamily Clitellariinae

A study of both adults and larvae of the subfamilies Cyphomyiinae and Hermetiinae (James, pers. comm.) has shown that these two taxa are closely related to the Clitellariinae as defined by me (p. 13). For this reason, I have combined the Cyphomyiinae with the genus *Adoxomyia* to form the tribe Clitellariini and have reduced the subfamily Hermetiinae to tribal status.

The genus *Dieuryneura* has not been placed in either tribe due to a lack of characters, but it appears to be more closely allied to the Hermetiini than to the Clitellariini.

SUBFAMILIAL CHARACTERS.—As given in key to subfamilies.

HABITAT OF LARVAE.—All larvae of this subfamily are terrestrial scavengers and, as such, have been reported from a great variety of habitats, the most common of which is decaying organic matter.

Tribe Clitellariini

This tribe includes 3 genera: *Adoxomyia*, *Cyphomyia*, and *Dicyphoma*. Their range extends from South America through the southwestern region of the United States. It is interesting to note that 2 species of *Adoxomyia*, *lata* and *rustica*, have extended their

range as far north as Oregon and Washington on the west coast and a third species, *subulata*, is found throughout many of the Eastern States. Fourteen species have been collected from the southwest as adults, but the genus *Adoxomyia*, which contains 11 of the 14 species, is known only from 3 puparia that lack the head capsule.

HABITAT OF LARVAE.—All specimens collected to date have been taken from decaying or wounded cactus. Larvae of an unknown species of *Cyphomyia* have been reported as occurring under the bark of cedar logs in Honduras.

Key to Genera of Clitellariini

1. Head without a distinct notch posterior to eye prominence; dorsal seta on median line of first abdominal segment shorter than outer 2 setae (fig. 77); all 3 setae set on a line perpendicular to the body axis . **Adoxomyia** Kertesz
   Head with a distinct notch posterior to eye prominence 2
2. Median seta on dorsum of first abdominal segment longer than setae on either side of it (fig. 84); all 3 setae set on a line diagonal to the body axis. **Cyphomyia** Wiedemann
   Median seta no longer than setae on either side of it (fig. 78); all 3 setae set on a line diagonal to the body axis . . . . . **Dicyphoma** James

Genus *Cyphomyia* Wiedemann, 1819

James (pers. comm.) recognizes 2 species in this genus: *Cyphomyia bicarinata* Williston and *C. marginata* Loew. Larvae have been collected for both species, but because the specimens of *C. bicarinata* are an early instar, pin mounted, and in poor condition, I have substituted the description of a neotropical species, *C. pilosissima* Gerstaecker.

Cyphomyia marginata Loew, 1866

FIGURES 152–154

DESCRIPTION.—Puparium: length 20.1 mm; width 2.9 mm; other characters as given in key to genera.

BIOLOGY.—Larvae of this species have been collected from papaya in Florida.

MATERIAL EXAMINED.—Florida: Miami, July 11, 1917, T. E. Snyder, 1 puparium, USNM.

Cyphomyia pilosissima Gerstaecker, 1857

FIGURES 83–85

DESCRIPTION.—Mature larva: length 21 mm; width 5 mm; dorsally the anterior and posterior margins of the thoracic and of the first 7 abdominal segments somewhat elevated with low transverse ridges occupying approximately the anterior and posterior fourth or fifth of the segment; ventrally these areas are only slightly elevated.

BIOLOGY.—Larvae of *C. bicarinata* as well as larvae of *C. pilosissima* have been taken from wounds in cacti, *C. bicarinata* from prickly pear (*Opuntia* species), and *C. pilosissima* from maguey (*Agave* species). No other data are available.

Genus *Dicyphoma* James, 1937

Only 1 species, *Dicyphoma schaefferi* (Coquillett), occurs in the Nearctic area. It is restricted to the southwestern states, where it has been taken from wounded and decaying cacti.

GENERIC CHARACTERS.—As given in key to genera.

Dicyphoma schaefferi (Coquillett), 1904

FIGURES 78, 81, 82

DESCRIPTION.—Mature larva: length 14.0–15.8 mm, mean 15.2 mm; width 3.6–4.1 mm, mean 3.87 mm.

BIOLOGY.—Larvae have been collected from *Opuntia* (*Platyopuntia*) species and *Myrtillocactus geometrizans* in Mexico.

MATERIAL EXAMINED.—Mexico: 54 miles north of San Luis Potosi, S.L.P., Aug. 4, 1960, Ryckman, Ryckman and Christianson, ADM 61, 2 larvae, WSU; 8 miles south of Aguascalientes, June 19, 1960, ADM 46, Ryckman, Ryckman and Christianson, 1 larva WSU. Texas: El Paso, Aug. 12, 1908, F. C. Pratt, 1 headless puparium, USNM.

DISCUSSION.—Except for the key characters, there appears to be little difference between the larva of *D. schaefferi* and that of *C. pilosissima*.

Genus *Adoxomyia* Bezzi, 1903

James (pers. comm.) lists 11 species for this genus, all of which (except *A. subulata*, *A. lata*, and *A. rustica*) are confined to the southwestern and western states. Unfortunately, this group of species is represented by only 3 puparia, all of which lack the head capsule; however, in an attempt to present a complete analysis of the generic characters, I have included the description of an Indian species, *Adoxomyia heminopla* (Wiedemann).

GENERIC CHARACTERS.—As given in key to genera.

Adoxomyia rustica (Osten Sacken), 1877

FIGURES 155, 156

DESCRIPTION.—Puparium: length 19.6 mm (head capsule missing); width 2.8 mm. Other characters as given in key to genera.

BIOLOGY.—No data available for *A. rustica* but larvae of *A. claripennis* have been collected from decaying cacti.

MATERIAL EXAMINED.—Washington: Tampico, Mar. 1, 1931, A. R. Rolfs, 1 puparium, USNM.

DISCUSSION.—In addition to the specimens described above, the author has examined 2 puparia of *A. claripennis* that were collected in Pima County, Ariz., Dec. 27, 1951, by Ryckman, Ames, and Arakawa USNM. Both specimens lacked the head capsule but were in agreement with other key characters of *A. rustica*.

***Adoxomyia heminopla* (Wiedemann), 1819**

FIGURES 74, 77, 80

DESCRIPTION.—Mature larva: the characters that appear to be of generic significance are given in the key to genera. Specific characters are unimportant since the species does not occur within the geographic range covered in this paper.

BIOLOGY.—Larvae of this species were collected from *Kaempferia* species, a tuberous-rooted plant. It has also been reported from papaya by Brunetti (1923).

MATERIAL EXAMINED.—India: Calcutta, May 26, 1955, HO–19477, lot no. 55–11257, 10 larvae, 5 puparia, USNM.

Tribe Hermetiini

Composed of the single genus *Hermetia*, this tribe is represented in North America by 8 species. Seven of them appear to be restricted to the southwestern United States. One species, *Hermetia illucens* (Linnaeus), has been recorded from as far north and east as Maryland and Delaware.

TRIBAL CHARACTERS.—As given in key to subfamilies.

HABITAT OF LARVAE.—Hermetiine larvae are terrestrial scavengers. They have been reported from excrement (mammal and avian), decaying vegetable matter, wax in beehives, and a cadaver (Dunn, 1916). *H. illucens* has been involved in the human disease enteric myiasis (James, 1947).

Key to Species of *Hermetia* Latrielle

1. Lateral and transverse setae (dorsal and ventral) very prominent; body segments with dense yellow pubescence especially on apical segment and on lateral margins . . . . . **illucens** (Linnaeus)
   Lateral and transverse setae not prominent; dense yellow pubescence lacking or, if present on dorsum of thorax, then divided into 2 patches by a bare median line 2
2. Posteroventral region of head with coarse yellow pubescence; 2 setae in prothoracic leg group . . . . . species
   Bib on venter of head lacking (fig. 108); more than 2 setae in prothoracic leg group 3

3. Labrum barely extending beyond ocular lobes; point not drawn out, blunt appearance . . . . . **concinna** Williston
Labrum extending beyond ocular lobes, end portion drawn out into a tapering point . . . . . **aurata** Bellardi

Genus *Hermetia* Latreille, 1804

I have seen larvae or puparia of 4 of the 8 species listed by James (pers. comm.) for this genus. One species, however, remains unnamed.

Hermetia illucens (Linnaeus), 1758

FIGURES 21, 65, 75, 79

DESCRIPTIONS.—Mature larva: length 14.5–21.5 mm, mean 18.6 mm; width 4.8–6.5 mm, mean 5.8 mm; head and body segments reddish brown; spiracles present on lateral margin of segments 3–10, accompanied by a small papilla on segments 2–5; anus not armed with spines; no transverse series of short spines.

Penultimate instar: length 19.0–25.5 mm, mean 18.6 mm; width 4.0–5.5 mm, mean 4.8 mm; body segments white to creamy yellow, head and prothoracic spiracles almost black; anus armed with spines; all abdominal segments with a transverse series of darkly pigmented spines on venter near anterior margin.

BIOLOGY.—Larvae of *H. illucens* are terrestrial scavengers. They have been reported from beehives (Copello, 1926), decaying crabs (Buxton and Hopkins, 1927), decaying fruits and vegetables, catsup, animal cadavers, waste material in beehives, and from privies (James, 1947). May (1961) reported that large numbers of *H. illucens*, living and dead larvae, pupae, and some dead adults, were found in covered crocks containing tuna remains preserved in a solution of 10 percent formaldehyde. Furman, Young, and Catts (1959) have shown that large numbers of larvae of *H. illucens* will prevent development of larvae of the housefly *Musca domestica* (Linnaeus) in poultry manure.

A detailed life history has been presented by May (1961) in which she reports on the time required for the egg, larval and pupal stadia, number of instars, and the morphological changes associated with each of the 6 larval instars.

In North America this species appears to be limited to one generation per year with the adults emerging in the spring after a winter of dormancy. Copello (1926) mentioned that mating takes place during flight and later the females oviposit at the edge of decaying organic material.

MATERIAL EXAMINED.—Arkansas: Fayetteville, Sept. 27, 1927, W. J. Baerg, 3 larvae from kraut. California: 10 miles east of

Rosario Cirio, June 29, 1938, Ross and Michelbacher, 12 larvae. Delaware: Magnolia, October 1958, P.P.B., 10 larvae from polluted water, UD; Primehood Neck, M.S.C., 8 larvae from lima bean cull pile, UD; Thompsonville, Oct. 24, 1957, M.S.C., 1 larva from lima bean refuse pile, UD. Florida: Collection 1884 from USNM, 5 larvae, 1 pupa, USNM. Georgia: Bissel, Sept. 15, 1938, 1 larva from rotten potatoes; Camp Stewart, Sept. 21, 1944, E. R. Willis, 8 larvae taken from pit latrine; Camp Stewart, Dec. 6, 1944, E. R. Willis, 31 larvae taken from pit latrine. Louisiana: Baton Rouge, Sept. 30, 1959, H. V. Daley, 13 larvae from chicken manure, LSU. Maryland: Beltsville, Aug. 9, 1957, J. C. Hwang, 4 larvae from turkey manure, USNM. Missouri: St. Louis, July 20, 1960, C. W. Robinette, 4 larvae, UMO. New Mexico: Roswell, Aug. 30, 1957, 7 larvae taken from worm bed. North Carolina: Clay County, Oct. 15, 1954, extension service, 5 larvae from silo, NCSC; Clayton County, July 5, 1959, W. Brooks, 6 larvae from corn pile, NCSC; Faison, Aug. 14, 1952, Dogger and Howden, 9 larvae from rotting pumpkin, NCSC; Fuguay, Sept. 12, 1950, 5 larvae from manure, NCSC; Long Beach, Sept. 5, 1951, 1 larva from refuse, NCSC; Onslow County, Sept. 18, 1956, H. E. Scott, 2 larvae from poultry litter, NCSC; Raleigh, Aug. 4, 1941, 8 larvae from garbage, NCSC; Raleigh, July 1, 1953, D. M. Weisman, 3 larvae from ensilage, NCSC; Raleigh, Sept. 4, 1954, W. Spink, 5 larvae, NCSC; Rockingham, Oct. 25, 1955, M. Farrier, 4 larvae from under caged hens, NCSC. South Carolina: Clemson, Nov. 18, 1959, Schroeder and Skelton, 2 larvae from lab culture (dung), CC; Clemson, Nov. 19, 1959, 1 larva from manure, CC; Clemson, 30 larvae (no data), CC; Wild Cat Creek, Six Mile, Sept. 29, 1959, D. H. Peterson, 1 larva, CC. Tennessee: Knoxville, Harwood, 1 pupal case. Washington: Everett, June 22, 1957, F. Johansen, 10 larvae from soy beans in freight car, origin unknown, WSU.

Hermetia concinna Williston, 1900

FIGURES 66, 69, 72

DESCRIPTION.—Puparium: length 17.3 mm; width 4.8 mm; head and body segments testaceous; no spines in transverse series on any segments.

BIOLOGY.—The puparium studied was taken from decayed sotol (*Dasylirion* species). No other data are available.

MATERIAL EXAMINED.—Arizona: Sierita Mountains, 30 miles southwest of Tucson, Nov. 27, 1913, E. A. Schwarz, 1 larva, 1 puparium, USNM.

***Hermetia* species**

FIGURES 68, 70, 76

DESCRIPTION.—Mature larva: length 17.5 mm; width 5.5 mm; head and body segments orange yellow, head more darkly pigmented at distal end; eyespots not distinct; transverse row of small spines present on segments 1–7 near anterior margin.

BIOLOGY.—Same as noted for *H. concinna*.

MATERIAL EXAMINED.—Three larvae with same data as for *H. concinna*.

DISCUSSION.—There may be some doubt as to the validity of this species because the specimens used to describe it were found with those of *H. concinna*.

***Hermetia aurata* Bellardi, 1859**

FIGURES 67, 71, 73

DESCRIPTION.—Puparium: length 17.8–22.3 mm, mean 20.05 mm; width 5.1–6.0 mm, mean 5.55 mm. Other characters as given in key to species.

BIOLOGY.—Larvae have been collected from prickly pear (*Opuntia occidentalis*).

MATERIAL EXAMINED.—California: San Dimas Canyon, Pomona, Los Angeles County, Dec. 4, 1960, A.D.M. 72, Ryckman and Olsen, two puparia, WSU.

Genus *Dieuryneura* James, 1937

***Dieuryneura obscura* (Coquillett), 1902**

FIGURES 16, 24, 27, 32

DESCRIPTION.—Mature larva: length 14.9 mm; width 4.0–4.3 mm, mean 4.1 mm; head and body segments dark brown.

BIOLOGY.—Larvae of this species were collected from a decaying sotol plant stem (*Dasylirion* species).

MATERIAL EXAMINED.—Texas: 12 miles north of Presidio, Apr. 18, 1952, 52–6319–Presidio–3119–L, 1 larva, 11 puparia, USNM.

Subfamily Stratiomyinae

This subfamily is composed of the species of Stratiomyidae, whose larvae are aquatic or semiaquatic. The larvae vary in size from a few millimeters to 50 millimeters. One commonly finds larvae of this subfamily as representatives of this family in general collections of immature stages. This can be explained best by the fact that the aquatic species are more numerous and, therefore, easier to locate than the terrestrial species.

SUBFAMILIAL CHARACTERS.—As given in key to subfamilies.

HABITAT OF LARVAE.—Stratiomyine larvae have been collected from almost every conceivable type of aquatic environment, ranging from hot springs and fast-flowing brooks to ocean shores. Although larvae in the genus *Stratiomys* are at home in water depths of several feet, larvae in most of the remaining genera prefer to remain hidden in naturally occurring vegetation along the shore or margin of the water. Quite frequently these larvae are found in and under shore debris such as boards, logs, cans, cardboard boxes, weeds, and other types of decaying organic matter.

Key to Genera of Stratiomyinae

1. Seventh abdominal segment of larva with curved sclerotized hooks on venter (fig. 122) 5
   Seventh abdominal segment without curved sclerotized hooks on venter . 2
2. Antenna located at apex of ocular lobe (fig. 126) 4
   Antenna not located at apex of ocular lobe . **Caloparyphus** James (in part)
3. Integument of larva covered with minute, peltate scales (fig. 91).
   Odontomyia Meigen, subgenus **Catasina**
   Integument lacking peltate scales . . . . . **Stratiomys** Geoffroy
4. Sclerotized hooks present on venter of each of the first 7 abdominal segments, those on the seventh larger than the others . . . . **Aochletus** Osten Sacken
   Sclerotized hooks absent from each of the first 6 segments; those on the seventh present 5
5. Hydrofuge setae on last abdominal segment attaching to 2-lobed structures on lower lip of spiracular cleft (fig. 88); prothoracic spriacles located at anterior corner of that segment . . . . . **Myxosargus** Brauer
   Hydrofuge setae attaching to straight edge of lower lip, lobed structures absent; prothoracic spiracle not located in anterior corner of prothorax . . 6
6. Antenna dorsal, not at apex of ocular lobe; prothoracic spiracles elevated or stalked 7
   Antenna at apex of ocular lobe; prothoracic spiracles neither elevated nor stalked 8
7. Apical segment with lateral margin straight; distance from antenna to eye prominence greater than twice length of antenna.
   Caloparyphus James (in part)
   Lateral margin of apical segment tapering basally toward median line; distance from antenna to eye prominence approximately equal to length of antenna . . . . . **Euparyphus** Gerstaecker
8. Venter of sixth and seventh abdominal segments with sclerotized hooks . . 9
   Venter of only seventh abdominal segment with sclerotized hooks.
   Odontomyia Meigen, subgenus **Odontomyiina**
9. Body segments with broad dorsal vittae or body segments with fine white pubescence or multiple hooks.
   Odontomyia Meigen, subgenus **Odontomyia**
   Without the above combination of characters . . . **Hedriodiscus** Enderlein

Genus *Stratiomys* Geoffroy, 1762

This is one of the largest genera of soldier flies that occurs in North America. Of the 21 species listed by James (pers. comm.), I have seen associated larvae or puparia of 7 species.

GENERIC CHARACTERS.—As given in key to species

Key to Species of *Stratiomys* Geoffroy

(Although associated puparia of 7 species were available, I was able to separate only 1 species (*S. discaloides* Curran) from the remaining 6).

Length of last abdominal segment approximately 2 times the basal width of that segment . . . . . **discaloides** Curran

Length of last abdominal segment greater than 2 times the basal width of that segment . . . . . **adelpha** Steyskal, **badia** Walker, **barbata** Loew, **meigenii** Wiedemann, **norma** Wiedemann, **normula** Loew.

Stratiomys discaloides Curran, 1922

FIGURE 119

DESCRIPTION.—Puparium: length 31 mm, width 6.8 mm; head and body segments dark brown; faint dark markings at basal margin of body segments. Other characters as given in key to species.

BIOLOGY.—No data are available for this species.

MATERIAL EXAMINED.—Montana: Harlan Gulch, Rav. County, Jan. 9, 1932, C. B. Philip, 1 broken puparium, WSU.

Stratiomys species

FIGURES 20, 105–109

DESCRIPTION.—Puparium: length 31.3–41.0 mm; width 4.9–6.0 mm; color varying from grey brown to dark brown; markings same as for *S. discaloides*. Other characters as given in key to species.

BIOLOGY.—See biology section in this paper.

MATERIAL EXAMINED.—*Stratiomys adelpha* Steyskal: New York: Ithaca, Decker Pond, Mar. 27, 1950, H. H. Schwardt, 1 puparium, WSU. Saskatchewan: Watson, May 15, 1956, M. E. Taylor, 5 puparia, MWM. *Stratiomys badia* Walker: Alberta: 4 miles north of Devon, May 16, 1961, G. Pritchard, 1 puparium, MWM; Banff National Park, Mt. Ishbel, June 14, 1960, Ball, Madge and McFadden, 1 larva, 1 puparium from under moss, elevation approximately 6000 ft., MWM. *Stratiomys barbata* Loew: Manitoba: Churchill, July 16, 1949, 2 puparia, CNC. Alberta: Banff National Park, Mt. Ishbel, June 14, 1960, Ball, Madge and McFadden, 1 puparium, elevation approximately 6000 ft., MWM. *Stratiomys meigenii* Wiedemann: Kansas: Manhatten, Feb. 8, 1936, H. H. Schwardt, 2 puparia, WSU. *Stratiomys norma* Wiedemann: Wisconsin: T9N Knapps Creek, Richland County, R2W, June 10, 1954, R. H. Jones, 4 puparia, WSU.

Stratiomys normula Loew: Louisiana: Baton Rouge (?), 2 puparia, LSU.

Genus *Myxosargus* Brauer, 1882

Four species of *Myxosargus* occur in North America but only the puparium of *Myxosargus nigricornis* Green is known.

GENERIC CHARACTERS.—As given in key to genera.

Myxosargus nigricornis Green, 1918

FIGURES 88, 92, 93

DESCRIPTION.—Puparium: length 6.7–7.0 mm (less head and prothorax), mean 6.85 mm; width 2.0–2.1 mm, mean 2.05 mm.

BIOLOGY.—No data are available for this species.

MATERIAL EXAMINED.—Missouri: 5 miles north of Vichy, June 15, 1955, P. J. Spangler, 2 puparia, WSU.

Genus *Euparyphus* Gerstaecker, 1857

James (pers. comm.) divided this genus into 2 subgenera as follows: *Euparyphus* (11 species) and *Aochletus* (3 species). Of the 11 species listed for *Euparyphus*, only the larvae of *E. limbrocutris* Adams have been collected. *Aochletus* has been elevated to full generic status.

GENERIC CHARACTERS.—As given in key to genera.

Euparyphus limbrocutris Adams, 1903

FIGURES 94, 95, 99

DESCRIPTION.—Mature larva: length 10.6–11.2 mm, mean 10.9 mm; width 2.3–2.5 mm, mean 2.4 mm; prothoracic spiracles located on a medial-lateral projection and extending at least halfway to the dorsomedian line of that segment.

Penultimate instar: length 9.2–10.6 mm, mean 9.9 mm; width 2.0–2.1 mm, mean 2.05 mm; differs from mature larva since prothoracic spiracles are elevated as high as their basal diameter.

BIOLOGY.—No data are available for this species.

MATERIAL EXAMINED.—Washington: O'Sullivan Dam, Grant County, May 7, 1955, J. A. Quist, 2 mature and 2 penultimate instar larvae, WSU.

Genus *Aochletus* Osten Sacken, 1886

On the basis of adult characters, James (pers. comm.) considered *Aochletus* to be a subgenus of *Euparyphus;* however, the difference or degree of difference between the larvae of *Aochletus* and *Euparyphus* is so great that I feel full generic status should be given to *Aochletus*.

Of the 3 species listed by James (pers. comm.) for this taxon, larvae have been collected for the following 2: *A. cinctus* Osten Sacken and *A. brevicornis* Loew.

GENERIC CHARACTERS.—As given in key to genera.

Key to Species of *Aochletus* Osten Sacken

Prothoracic spiracles distinctly stalked . . . . . **cinctus** Osten Sacken
Prothoracic spiracles almost flush with integument . . . . . **brevicornis** Loew

Aochletus cinctus Osten Sacken, 1866

DESCRIPTION.—Puparium: length 9.5–10.5 mm, mean 10.0 mm; width 2.7–2.8 mm, mean 2.73 mm. Other characters as given in key to species.

BIOLOGY.—No data are available for this species.

MATERIAL EXAMINED.—California: Topanga Canyon, Los Angeles County, May 10, 1953, 3 puparia, WSU; Sespe Creek, Ventura County, June 15, 1948, W. W. Wirth, 1 puparium, USNM.

Aochletus brevicornis Loew, 1866

FIGURES 96, 97, 101

DESCRIPTION.—Instar no. ?: length 4.5–5.3 mm, mean 4.93 mm; width 1.3–1.7 mm, mean 1.50 mm; other characters as given in key to species.

BIOLOGY.—Larvae have been collected from springs in Yellowstone National Park. No mention is given regarding the type of spring other than the location.

MATERIAL EXAMINED.—Wyoming: Mammoth, Yellowstone National Park, Jan. 25, 1956, J. R. Murphy, 3 early instar larave from a cavern spring, WSU; Mammoth, Yellowstone National Park, June 20, 1956, J. R. Murphy, 6 larvae from hillside springs, WSU.

Genus *Caloparyphus* James, 1939

On the basis of male genitalia, both James (pers. comm.) and Quist (Thesis) consider *Caloparyphus* to merit generic status. The larvae, however, do not seem to corroborate this. In fact, it is rather difficult to distinguish between the larvae of *Caloparyphus* and those of *Euparyphus* (see key to genera, p. 33). This seems to suggest that perhaps *Caloparyphus* should be returned to its former status as a subgenus of *Euparyphus*.

James (pers. comm.) lists 11 species for this genus in North America. Associated larvae or puparia have been collected for 5 species, including 1 unidentified species.

GENERIC CHARACTERS.—As given in key to genera.

Key to Species of *Caloparyphus* James

1. Venter of seventh abdominal segment without strong sclerotized hooks. . . . . species
   Venter of seventh abdominal segment with strong sclerotized hooks . . . 2
2. Sclerotized hooks half the length of seventh abdominal segment. . . . . **amplus** (Coquillett)
   Sclerotized hooks less than half the length of the seventh abdominal segment 3
3. Prothoracic spiracle oval shaped, diameter at widest point twice that of the elevation; 4 setae in mesothoracic leg group . . . . . **major** (Hine)
   Prothoracic spiracle varying in shape but elevation approximately equal to basal diameter; number of setae in mesothoracic leg group other than 4 . 4
4. Three setae in mesothoracic leg group . . . . . **tetraspilus** (Loew)
   Five setae in mesothoracic leg group . . . . . **crotchi** (Osten Sacken)

Caloparyphus species

FIGURES 112, 115, 118

DESCRIPTION.—Puparium: length 12.4–13.4 mm, mean 12.88 mm; width 2.5–3.2 mm, mean 2.90 mm; other characters as given in keys to genera and species.

BIOLOGY.—Larvae of this species were collected from a sphagnum bog located part way up a mountain (elevation approximately 6000 ft.).

MATERIAL EXAMINED.—Alberta: Banff National Park, Mt. Ishbel, Apr. 14, 1960, Ball, Madge and McFadden, 5 puparia, MWM.

Caloparyphus amplus (Coquillett), 1902

FIGURES 122, 127, 128, 131

DESCRIPTION.—Mature larva: length 7 mm or under; width 1.0–1.4 mm, mean 1.2 mm; dorsum of body segments with short blunt setae; other characters as given in key to species.

BIOLOGY.—No data are available for this species.

MATERIAL EXAMINED.—California: Sespe Creek, Ventura County, June 15, 1948, W. W. Wirth, 20 larvae, USNM.

DISCUSSION.—Accurate measurements of length were unobtainable due to improper preservation of the specimens.

Caloparyphus major (Hine), 1901

FIGURES 111, 114, 117

DESCRIPTION.—Mature larva: length 9.6–12.1 mm, mean 10.94 mm; width 2.7–2.9 mm, mean 2.8 mm; other characters as given in key to species.

BIOLOGY.—Larvae of this species were collected from moss on a large floating board in a cold, spring-fed roadside pool.

MATERIAL EXAMINED.—British Columbia: Pole no. 187/18, Route 3, June 9, 1960, Ball, Madge, and McFadden, 5 larvae, 3 puparia, MWM.

***Caloparyphus tetraspilus* (Loew), 1866**

FIGURES 110, 113, 116

DESCRIPTION.—Mature larva: length 9.5–11.0 mm, mean 10.25 mm; width 1.8–2.3 mm, mean 2.05 mm; other characters as given in key to species

BIOLOGY.—Larvae of this species were collected on a sandy lake beach under decaying vegetation and other debris at the water's edge.

MATERIAL EXAMINED.—Alberta: Dilberry Lake, 54°34′30″ N lat., 110°60′45″ W long., June 5, 1960, Ball, Madge and McFadden, 2 larvae, MWM.

***Caloparyphus crotchi* (Osten Sacken), 1877**

FIGURES 125, 129, 132

DESCRIPTION.—Puparium: length (specimen broken, impossible to measure accurately but close to 15 mm); width 3.4 mm; other characters as given in key to species.

BIOLOGY.—No data are available for this species.

MATERIAL EXAMINED.—Colorado: Fort Collins, Aug. 4, 1910, 1 puparium, WSU.

Genus *Hedriodiscus* Enderlein, 1914

James (pers. comm.) lists 7 species for this genus in North America. Only the larva of *H. vertebratus* (Say) is known.

***Hedriodiscus vertebratus* (Say), 1824**

FIGURES 87, 91

DESCRIPTION.—Puparium: length 19 mm, width 2.7 mm; other characters as given in key to genera

BIOLOGY.—James (pers. comm.) reported that larvae of this species live among floating vegetation in small streams. They feed on microorganisms, algae, and the soft parts of plants.

MATERIAL EXAMINED.—Locality (?); July 1, 1938, larva from weedy lake, 1 puparium, WSU.

Genus *Odontomyia* Meigen, 1803

James (pers. comm.) has divided this taxon into 3 subgenera as follows: *Catasina* (9 species), *Odontomyiina* (7 species) and *Odontomyia* (14 species). The character combinations of the immature stages seem to support this classification.

Subgenus *Catasina* Enderlein, 1914

Odontomyia (*Catasina*) *pubescens* (Day), 1882

FIGURES 86, 89, 90

DESCRIPTION.—Puparium: length 13.8–17.0 mm, mean 15.80 mm; width 2.7–3.6 mm, mean 3.1 mm; other characters as given in key to genera.

BIOLOGY.—Larvae of this species have been collected from moss-covered logs (in boggy areas), from under stones at water's edge, and from the margins of marshy areas.

MATERIAL EXAMINED.—Alberta: Beaverhills Lake near Tofield, May 21, 1960, G. E. Ball, 1 puparium, MWM; Flatbush, May 12, 1960, M. W. McFadden, 1 larva, 1 puparium, MWM; Dilberry Lake, 54°34′30″ N lat., 110°60′45″ W long., June 5, 1960, Ball, Madge, and McFadden, 1 puparium, MWM. Saskatchewan: Saskatoon, May 15, 1949, A. R. Brooks, 1 puparium, CNC.

Subgenus *Odontomyiina* Enderlein, 1930

Odontomyia (*Odontomyiina*) *virgo* (Wiedemann), 1830

FIGURES 98, 102

DESCRIPTION.—Puparium: length 15 mm (less head and prothorax); width 3.50 mm; 4 white vittae on dorsal surface of body segments, inner 2 narrow; penultimate segment half as long as apical segment; other characters as given in key to genera.

BIOLOGY.—Larvae of this species were collected from shore debris at the edge of a small pond.

MATERIAL EXAMINED.—Alberta: 4 miles north of Devon, May 10, 1961, M. W. McFadden, 1 puparium, 1 early instar larva, MWM.

Subgenus *Odontomyia* Meigen, 1803

Key to Species of *Odontomyia* Meigen

1. Venter of sixth and seventh abdominal segments with multiple hooks. **occidentalis** James
   Venter of sixth and seventh abdominal segments with a single pair of hooks . 2
2. Dorsum with 2 broad vittae extending length of body but dividing into 4 vittae on apical segment . . . . . **cincta** Olivier
   Vittae in different pattern; body segments with fine white pubescence. **communis** James

***Odontomyia (Odontomyia) occidentalis* James, 1936**

FIGURES 135, 136, 138

DESCRIPTION.—Puparium: length 20 mm; width 3.5 mm; other characters as given in key to species.

BIOLOGY.—Larvae of this species have been collected from hot springs.

MATERIAL EXAMINED.—Sleeping Child Hot Springs, reared June 28, 1930, 2 puparia, WSU.

DISCUSSION.—The mensural data given above were taken directly from the puparia. These specimens had the apical segments turned up in the typical manner making accurate measurements an impossibility.

***Odontomyia (Odontomyia) cincta* Olivier, 1811**

FIGURES 126, 130, 133

DESCRIPTION.—Mature larva: length 18.5–20.0 mm, mean 19.25 mm; width 3.5–3.9 mm, mean 3.7 mm; other characters as given in key to species.

BIOLOGY.—Larvae of this species have been collected from a peat bog and from a pool of unidentified type.

MATERIAL EXAMINED.—Ohio: Delaware County, July 29, 1940, 1 larva, OSU. Wisconsin: Dane County, University of Wisconsin Arboretum, May 22, 1954, R. H. Jones, 1 puparium, WSU.

***Odontomyia (Odontomyia) communis* James, 1939**

FIGURES 140, 142

DESCRIPTION.—Mature larva: length 19–21 mm, mean 20 mm; width 2.9–3.6 mm, mean 3.25 mm; other characters as given in key to species.

BIOLOGY.—Larvae of this species have been collected from 5 percent saline water in Death Valley.

MATERIAL EXAMINED.—California: Bad Water, Death Valley, May 1, 1958, D. P. Furman, 2 larvae, WSU.

Subfamily Nemotelinae

James (pers. comm.) placed the genus *Nemotelus* in the Stratiomyinae solely on the basis of adult characters; however, when both adult and larval characters are taken together and compared with similar characters of other members of that subfamily, the differences observed are great enough to warrant separation. For this reason I have erected the new subfamily Nemotelinae.

SUBFAMILIAL CHARACTERS.—As given in key to subfamilies.

Genus *Nemotelus* Geoffroy, 1762

In North America this genus contains 33 species that are divided into 2 subgenera: *Nemotelus* (12 species) and *Camptopelta* (21 species). I have seen puparia of 2 species of *Camptopelta* and larvae of a single species of *Nemotelus*.

GENERIC CHARACTERS.—As given in key to genera.

Subgenus *Nemotelus* Geoffroy, 1762

The specimens representing this taxon consisted of 3 headless puparia in poor condition.

Nemotelus (Nemotelus) kansensis Adams, 1903

FIGURES 120, 123

DESCRIPTION.—Puparium: length 7.2 mm (less head and prothorax); width 2.6 mm

BIOLOGY.—Larvae of this species were collected from a salt spring (probably from the margin)

MATERIAL EXAMINED.—Missouri: Petersburg, June 1, 1955, P. J. Spangler, 3 puparia, WSU.

DISCUSSION.—The pattern on the dorsum of the body segments and the arrangement and placement of setae both agree very closely with that of *Nemotelus canadensis* Loew

Subgenus *Camptopelta* Williston, 1917

Key to Species of *Camptopelta* Williston

Larva less than 4 mm in length; dorsum of body segments lacking vittae and plaques . . . . . **centralis** Hanson

Larva 5 mm or more in length; dorsum of body segments with vittae and plaques (fig. 121) . . . . . **canadensis** Loew

Nemotelus (Camptopelta) centralis Hanson, 1953

FIGURES 100, 103, 104

DESCRIPTION.—Mature larva: length 3.5–3.7 mm, mean 3.6 mm; width 0.8–1.0 mm, mean 0.9 mm; head light brown, body white; prothoracic spiracles dark.

BIOLOGY.—No data are available for this species.

MATERIAL EXAMINED.—Michigan: Cheboygan County, Aug. 17, 1957, W. J. Hanson, 3 larvae, lab reared, KU

Nemotelus (Camptopelta) canadensis Loew, 1863

FIGURES 121, 124, 134

DESCRIPTION.—Puparium: length 7.7–8.3 mm, mean 8.0 mm; width 1.8–2.0 mm, mean 1.9 mm; other characters as given in key to species.

221-533—66——4

BIOLOGY.—Larvae of this species have been collected from under cow manure and rotting vegetation at the edge of highly alkaline lakes (pH 8.6).

MATERIAL EXAMINED.—Alberta: Chappice Lake, 18 miles north of Medicine Hat, June 7, 1960, Ball, Madge and McFadden, 3 puparia, MWM; Gooseberry Lake Provincial Park, 9 miles north of Consort, June 5, 1960, Ball, Madge and McFadden, 8 puparia, MWM.

Subfamily Pachygastrinae

In their recent revision of this subfamily, Kraft and Cook (1961) have presented an up-to-date resumé of the biology and taxonomy of both adults and larvae. Keys were presented for distinguishing between larvae in each of the 5 genera and within the 2 genera *Zabrachia* and *Eupachygaster*.

I have found variation in the measurements given by Kraft and Cook as compared with those taken by myself. In one species, *Eupachygaster henshawi* Malloch, this variation is one millimeter and represents an error of 25 percent. In spite of this, I do not believe that these mensural variations represent specific differences but, rather, indicate a small sample that may have been taken from a limited geographic area. I have placed the measurements given by Kraft and Cook in brackets and have presented my own measurements including range and mean.

SUBFAMILIAL CHARACTERS.—As given in key to subfamilies.

HABITAT OF LARVAE.—Pachygastrine larvae have been found under the bark of both deciduous and coniferous trees. Oviposition usually occurs on wounded or dead trees but in either case there must be enough moisture present in the host for the larvae to be able to obtain nourishment. Host trees mentioned by Kraft and Cook are: apple, quaking aspen, dwarf elm, American elm, cottonwood, hickory, white pine, Douglas fir, Engelmann spruce, and shore pine.

The larvae are gregarious (I have collected approximately 100 larvae beneath the bark of a single log), extremely slow moving, and feed on the sap or microorganisms that occur in the moist areas beneath the bark. Malloch (1917) has suggested that pachygastrine larvae are predatory on other insect larvae but this has not been observed.

Key to Genera of Subfamily Pachygastrinae

(modified after Kraft and Cook, 1961)

1. Teeth along anal opening prominent; setae on margin of last segment short, no longer than one-fourth width of last segment (fig. 141) 2
   No prominent teeth along anal opening; setae on margin of last segment long, at least one-third as long as width of last segment (fig. 140) 3

2. Midventral line of abdominal segment 6 with a round sternal patch, located anterior to transverse row of setae; 8 or more pairs of conspicuous plaques along dorsal midline of last segment . . . . . **Berkshiria** Johnson
Sternal patch on midventral line of abdominal segment 6 oval, located between setae of transverse row; no more than 3 or 4 pairs of conspicuous plaques along dorsal midline of last segment . . . . . **Neopachygaster** Austen
3. Each thoracic leg group with 2 setae (fig. 140) . . . **Eupachygaster** Kertesz
Each thoracic leg group with 3 setae (fig. 142) 4
4. Abdominal segments 1–7 each with 18 setae (fig. 148). . **Pachygaster** Meigen
Abdominal segments 1–7 each with 20 setae (fig. 142). **Zabrachia** Coquillett

Genus *Berkshiria* Johnson, 1914

This genus contains the single species *Berkshiria albistylum*, the larva of which has been collected from beneath the bark of deciduous trees only. As Kraft and Cook (1961) have pointed out, it resembles *Neopachygaster* but can be readily distinguished on the basis of the form of the sternal patch.

GENERIC CHARACTERS.—As given in key to genera.

Berkshiria albistylum Johnson, 1914

FIGURE 142

DESCRIPTION.—Mature larva: length (5.0–7.2 mm) 5.0–5.9 mm, mean 5.3 mm; width (1.6–2.0 mm) 2.0–2.4 mm, mean 2.2 mm.

BIOLOGY—Larvae of *B. albistylum* have been collected from under the bark of poplar (*Populus deltoides*) and elm (*Ulmus pumila*). Cook (1953) reported that the larvae have at least 4 instars that apparently do not form distinct size groups. He also mentioned that the pupal period lasted from 8 to 10 days and that the adults did not live for more than 5 days in the laboratory.

MATERIAL EXAMINED.—Eight larvae from the Ohio State University collection with the following data: Dec. 5, 1942, under bark of dead poplar.

Genus *Zabrachia* Coquillett, 1901

Of the 11 species listed for this genus by Kraft and Cook (1961), the larvae of only 2 species have been found. Both species were taken from beneath the bark of coniferous trees.

GENERIC CHARACTERS.—As given in key to genera.

Key to Species of *Zabrachia* Coquillett

(after Kraft and Cook, 1961)

Ventral surface of abdominal segment 6 with 18 large plaques . **politum** Coquillett
Ventral surface of abdominal segment 6 with 16 large plaques.
plicatum Kraft and Cook

Zabrachia politum Coquillett, 1901

FIGURE 145

DESCRIPTION.—Mature larva: length 4.3 mm; width 1.0 mm; other characters as given in key to species.

BIOLOGY—No data are available for this species.

MATERIAL EXAMINED.—No larvae of this species were examined.

Zabrachia plicatum Kraft and Cook, 1961

FIGURE 142

DESCRIPTION.—Mature larva: length 4.0–5.0 mm, mean 4.7 mm; width 0.7–1.0 mm, mean 0.5 mm; other characters given in key to species.

BIOLOGY.—Larvae have been collected from beneath the bark of *Pinus contorta*, *P. ponderosa*, *Picea engelmanni*, and *Pseudotsuga mucronata*.

MATERIAL EXAMINED.—North Carolina: Raleigh, 1941–1942, 9 larvae from fallen pine, NCSC.

DISCUSSION.—In keying out this species, I found it necessary to slide-mount the integument in order to be sure of the number of plaques on segment 6.

Genus *Neopachygaster* Austen, 1901

Kraft and Cook (1961) recognize 4 species in this genus. The larvae have been collected from both coniferous and deciduous trees.

GENERIC CHARACTERS.—As given in key to genera.

Key to Species of *Neopachygaster* Austen

Kraft and Cook (1961) were unable to differentiate between the larvae of the species in this genus. Because of a lack of material, I am also unable to contribute toward the identification of these species.

Neopachygaster occidentalis Kraft and Cook, 1961

FIGURE 147

DESCRIPTION.—Larva: length 5.58 mm; width 1.69 mm; tufts of setae of thoracic leg group with 2 inner seate of equal length, outer seta much shorter; otherwise indistinguishable from other larvae of this genus.

BIOLOGY.—Larvae were taken from under bark of *Pinus ponderosa*.

MATERIAL EXAMINED.—No larvae of this species were examined.

DISCUSSION.—All data presented for this species are taken directly from Kraft and Cook (1961).

Neopachygaster maculicornis (Hine), 1902

FIGURES 18, 146

DESCRIPTION.—Mature larva: length (5.50–6.00 mm) 6.0–6.5 mm, mean 6.17 mm; width (1.40–1.50 mm) 1.1–1.50 mm, mean 1.27 mm; tufts of setae in thoracic leg group same as in *N. occidentalis*.

BIOLOGY.—Larvae have been collected from beneath the bark of a fallen poplar (*Populus* species).

MATERIAL EXAMINED.—Alberta: Medicine Hat, South Saskatchewan River, June 7, 1960, Ball, Madge, and McFadden, approximately 100 specimens of larvae and puparia, MWM.

DISCUSSION.—Adults of this species were reared from larvae and the measurements outside of the parentheses are based on these specimens.

Neopachygaster vitrea Hull, 1930

DESCRIPTION.—According to Kraft and Cook (1961), the larva of this species is essentially the same as the larva of *N. maculicornis*.

BIOLOGY.—No data are available for this species.

MATERIAL EXAMINED.—No larvae of this species were examined.

Neopachygaster reniformis Hull, 1942

DESCRIPTION.—Larva: length 4.93 mm; width 1.45 mm; very similar to larvae of *N. maculicornis;* tufts of thoracic leg setae with the middle setae longest, inner seta next longest.

BIOLOGY.—No data are available for this species.

MATERIAL EXAMINED.—No larvae of this species were examined.

DISCUSSION.—All data presented for this species were taken directly from Kraft and Cook (1961).

Genus *Euphachygaster* Kertesz, 1911

Kraft and Cook (1961) recognize 3 species in this genus. The larvae have been collected from beneath the bark of both deciduous and coniferous trees.

GENERIC CHARACTERS.—As given in key to genera.

Key to Species of *Eupachygaster* Kertesz

(modified after Kraft and Cook, 1961)

1. Abdominal terga 1–7 of approximately equal length with setae in transverse rows . . . . . **punctifer** Malloch
   Setae in transverse rows with the outermost setae much shorter than the others in the row 2

2. Transverse row of 6 setae on abdominal sterna 1–7 with all setae of approximately equal length . . . . . **henshawi** Malloch
Setae in transverse row with outermost setae much longer than others. **fusca** Kraft and Cook

Eupachygaster punctifer Malloch, 1915

FIGURE 143

DESCRIPTION.—Mature larva: length (6.2 mm) 5.0–6.5 mm, mean 5.8 mm; width (1.7 mm) 1.0–1.3 mm, mean 1.2 mm; other characters as given in key to species.

BIOLOGY.—Larvae have been collected from under the bark of *Carya*, *Populus*, and an unknown species of *Pinus*.

MATERIAL EXAMINED.—Delaware: Sussex County, 1952, W. A. Connell, 6 larvae from under bark, UD. North Carolina: Auburn, Nov. 2, 1956, Bowden and Wright, 3 larvae from under bark of oak log, NCSC; Herring, August 23, 1956, C. G. Wright, 1 larva from under bark of oak log, NCSC; West End, July 14, 1941, 12 larvae from under bark of pine log, NCSC.

Eupachygaster fusca Kraft and Cook, 1961

FIGURE 140

DESCRIPTION.—Mature larva: length (5.85 mm) 4.2–7.0 mm, mean 6.0 mm; width (0.169 mm) 0.9–1.7 mm, mean 1.5 mm; other characters as given in key to species

BIOLOGY.—The only recorded host for this species is the willow (*Salix* species).

MATERIAL EXAMINED.—North Carolina: Rocky Mountain, Mar. 25, 1954, D. M. Weisman, 20 larvae from under bark of log, NCSC. Ohio: Wooster, Apr. 22, 1940, H. R. Dodge, 5 larvae from under willow bark, NCSC.

Eupachygaster henshawi Malloch, 1917

FIGURE 144

DESCRIPTION.—Mature Larva: length (4.95 mm) 5.7–6.9 mm, mean 6.5 mm; width (1.44 mm) 1.2–1.3 mm, mean 1.23 mm; other characters as given in key to species

BIOLOGY.—Larvae have been collected from under the bark of apple, elm, and oak trees.

MATERIAL EXAMINED.—North Carolina: Auburn, Jan. 8, 1956, C. G. Wright, 3 larvae from under bark of oak log, NCSC; Auburn, Aug. 25, 1956, C. G. Wright, 3 larvae from under bark of oak tree, NCSC.

Genus *Pachygaster* Meigen, 1803

Kraft and Cook (1961) list 3 species for this genus but larvae of only *Pachygaster pulchra* have been found.

GENERIC CHARACTERS.—As given in key to genera.

Pachygaster pulchra Loew, 1863

FIGURE 148

DESCRIPTION.—Larva: length 4.82 mm; width 0.94 mm; narrow, dirty white, dorsal setae knobbed at tips; only 9 pairs of setae on abdominal segments 1–7.

BIOLOGY.—Larvae of this species have been collected from tree crotch debris, treeholes, and hollow trees.

MATERIAL EXAMINED.—No larvae of this species were examined.

DISCUSSION.—All data presented for this species were taken directly from Kraft and Cook (1961).

Literature Cited

AUSTEN, E. E.

1899. On the preliminary stages and mode of escape of the imago of the dipterous genus *Xylomyia* Rondani (*Subula* Meigen *et auct.*) with special reference to *Xylomyia maculata* F., and on the systematic position of the genus. Ann. Mag. Nat. Hist., vol. 3, no. 7, pp. 181–190.

BAKER, C. F.

1895. Biological notes on some Colorado Diptera. Ent. News, vol. 6, no. 6, p. 6.

BELING, T.

1883. Beitrag zur Metamorphose zweiflügeliger Insekten aus den Familien Tabanidae, Leptidae, Asilidae, Empidae, Dolichopidae, und Syphidae. Arch. Nat., vol. 48, pp. 186–240.

BELLARDI, L.

1861. Saggio di Ditterologia Messicana. Mem. Reale Accad. Sci. Torino, vol. 19, pp. 201–278.

BERG, C. O.

1952. Biology and metamorphosis of some Solomon Islands Diptera, 2: *Solva bergi* James (Erinnidae), with a comparison of related species. Pan-Pacific Ent., vol. 28, no. 4, pp. 203–215.

BERTRAND, H.

1948. Note sur deux larves du genre *Hermione* Meigen. Bull. Soc. Ent. France, vol. 53, pp. 55–58.

BISCHOFF, W.

1925. Ueber die Kopfbildung der Dipterenlarven, 3: Die Köpfe der Orthorrhapha-Brachycera-Larven. Arch. Naturg., vol. 90, pp. 1–105.

BORGMEIER, T.

1930. Ueber das Vorkommen der Larven von *Hermetia illucens* L. in den Nestern von Meliponiden. Zool. Anz., vol. 90, pp. 225–235.

BOUCHÉ, P. F.

1834. Naturgeschichte der Insekten besonders in Hinsicht ihrer ersten Zustande als Larven und Puppen.

BRAUER, F.

1869. Kurze Characteristik der Dipteren-Larven zur Bekraftigung des neuen von Dr. Schiner entwerfenen Dipterensystemes. Verh. Zool.-Bot. Ges. Wien, vol. 19, pp. 843–852.

1883. Die Zweiflüger des Kaiserlichen Museums zu Wien, 3: Systematatische Studien auf Grundlage der Dipterenlarven, nebst einer Zusammenstellung von Beispielen aus der Literatur über dieselben und Beschreibung neuer Formen. Denkschr. Kais. Akad. Wiss. Wien, vol. 47, pp. 1–100.

BREML

1846. Beitrag zur Kunde der Dipteren. Isis Oken, vol. 3, pp. 164–175.

BRINDLE, A.

1959. Notes on the larvae of the British Rhagionidae and Stratiomyidae. Ent. Rec., vol. 71, pp. 126–133.

BRONGNIART, C. J. E.
1881. Note sur les tufs quarternaires de Bernouville, pres Gisors (Eure). Bull. Soc. Geol. France, vol. 8, no. 3, p. 419.

BRUES, C. T.
1924. Observations on animal life in the thermal waters of Yellowstone Park, with a consideration of the thermal environment. Proc. American Acad. Arts Sci., vol. 59, pp. 371–437.
1928. Studies on the fauna of hot springs in the Western United States and the biology of thermophilous animals. Proc. American Acad. Arts Sci., vol. 63, pp. 139–228.
1932. Further studies on the fauna of North American hot springs. Proc. American Acad. Arts Sci., vol. 67, pp. 185–303.

BUXTON, P. A.
1929. A note on the larvae of four species of Stratiomyidae. *In* Insects of Samoa, vol. 6, pp. 141–150.

BUXTON, P. A., and HOPKINS, G. H. E.
1927. Researches in Polynesia and Melanesia. London: London School of Hygiene and Tropical Medicine, pts. 1–4, pp. 51, 65.

COLLART, A.
1937. Contribution à l'étude des diptères de Belgique (3° note). Bull. Ann. Soc. Ent. Belgique, vol. 77, pp. 306–317.

COOK, E. F.
1949. The evolution of the head in the larvae of Diptera. Microentomology, vol. 14, pp. 1–57.
1953. On the early stages of *Neopachygaster maculicornis* (Hine) and *Berkshiria aldrichi* (Malloch). Ann. Ent. Soc. America, vol. 46, pp. 293–299.

COPELLO, A.
1926. Biologia de *Hermetia illucens* Latr. Rev. Soc. Ent. Argentina, vol. 1, no. 2, pp. 22–26.

CORNELIUS, C.
1860. Zur Ernahrung und Entwicklung der Larven von *Sargus formosus* Schrank. Stettiner Ent. Zeit., vol. 21, pp. 202–204.

CROS, A.
1911. Notes sur les larves de *Stratiomys anubis* Wiedemann. Feuill. Jeun. Nat., vol. 41, pp. 91–103.

CURRAN, C. H.
1934. The families and genera of North American Diptera, pp. 135–145.

DAMIANITSCH, R.
1868. Ueber die Metamorphose des *Xylophagus ater* (Fab.). Verh. Zool.-Bot. Ges. Wien, vol. 18, pp. 117–118.

DUFOUR, L.
1841. Note sur la larve du *Pachygaster mesomelas*. Ann. Sci. Nat., vol. 16, no. 2, pp. 264–266.
1846a. Note sur la *Fulgora obliqua*, la *Brachyopa bicolor* et le *Subularia citripes*. Bull. Soc. Ent. France, vol. 4, p. 47.
1846b. Sur une colonie d'insectes vivant dan l'ulcére de l'ormeau. Compt. Rend. Acad. Sci. Paris, vol. 22, pp. 318–319.
1847. Histoire des metamorphoses du *Subula citripes* et quelques autres especes de ce genre des diptères. Ann. Sci. Nat., vol. 7, no. 3 pp. 5–14.

DUNN, L. H.
1916. *Hermetia illucens* breeding in a human cadaver. Ent. News, vol. 27, pp. 59–61.

DUSEK, J., and ROZKOSNY, R.
1963. Revision Mitteleuropaischer Arten der Familie Stratiomyidae (Diptera) mit besonderer Berucksichtigung der Fauna der GSSR. Act. Soc. Ent. Cechoslovenlae, vol. 60, no. 3, pp. 202–221.

ENGEL, E. O.
1916. Beitrage zur kenntnis einiger Dipteren larven. Mitt. Münchener Ent. Ges., vol. 7, pp. 68–76.

ENGEL, E. O., and CUTHBERTSON, A.
1937. On the biology of some Rhodesian Diptera together with descriptions of three species of Asilidae new to science. Trans. Rhodesia Sci. Assoc., vol. 35, pp. 1–15.

ENGELHARDT, G. P.
1928. Notes on the breeding of *Hermetia aurata* Bell. Bull. Brooklyn Ent. Soc., vol. 23, p. 122.

FANTHOM, H. B., and PORTER, A.
1913. *Herpetomonas stratiomyiae* n. sp., a flagellate parasite of the flies *Stratiomyia chamaeleon* and *Stratiomyia potamida*, with remarks on the biology of the hosts. Ann. Trop. Med. Parasit., vol. 7, pp. 609–620.

FARGEAU, S., and SERVILLE, J. G.
1825. Les larves du *Vappo* Latr. Fabr. (*Pachygaster* Meig., Macq.). *In* vol. 10 *of* Encyclopedie medthodique, p. 779.

FLORENTIN.
1899. Études sur la fauna des mares salees de Lorraine. Ann. Sci. Nat., pp. 274–276.

FREIDENFELS, E.
1880. Ueber *Artemia salina* und andere Bewohner der Soolenteiche in Salzburg. Verh. Mitth. Siebenbürgischer Ver. Naturwiss. (Hermannstadt), vol. 30, pp. 112–178.

FRISCH, J. L.
1720. Beschreibung von allerly Insecten in Teutsch-Land, nebst nutzlichen Anmerckungen . . . vondiesem . . . inlandischen Gewürme vol. 1, no. 5, p. 10.

FROGGAT, W. E.
1896. The entomology of the grass tree (*Xanthorrhoea*). Proc. Linn. Soc. New South Wales, vol. 21, pp. 74–87.

FULLER, M.
1934. The early stages of *Actina incisuralis*. Proc. Linn. Soc. New South Wales, vol. 59, pp. 190–196.

FURMAN, D. P.; YOUNG, R. D.; and CATTS, P. E.
1959. *Hermetia illucens* (Linnaeus) as a factor in the natural control of *Musca domestica* (Linnaeus). Journ. Econ. Ent., vol. 52, no. 5, pp. 917–921.

GANIN, M.
1876. Materialen zur Kenntniss der post embryonalen Entwickelungsgeschichte der Insekten: Protokolle der Sitzungen der Sektion für die Zoologie und vergleichende Anatomy der S. Versammlung russischer Naturforscher und Aerzte in Warschaw, Sept. Mitgeteilt von Hoyer.

GEER, C. DE
1778. Mémoires pour servir a l'histoire des insectes, 7 vols.
GOIDANICH, A.
1939. Gli straziomiidi mancati nemici del riso. Risicoltura, vol. 29, pp. 221–230.
GOUREAU, C.
1867. A note on *Subula*. Ann. Soc. Ent. France, ser., 4. vol. 7, pp. 87–88.
GREENE, C. T.
1917. A contribution to the biology of North American Diptera. Proc. Ent. Soc. Washington, vol. 19, pp. 146–161.
1926. Descriptions of larvae and pupae of two-winged flies belonging to the family Leptidae. Proc. U.S. Nat. Mus., art. 2, vol. 70, pp. 1–20.
GRIFFITH, H. G., and PACKARD, A. S.
1882. Larvae of *Stratiomyia* sp. found in a hot spring in Colorado. American Nat., vol. 16, pp. 599–600.
GRÜNBERG, K.
1910. Diptera. No. 2A *in* Brauer, Die Süsswasserfauna Deutschlands, iv+312 pp.
HALIDAY, A. H.
1857a. On some remaining blanks in the natural history of the native Diptera (larvae). Nat. Hist. Rev., vol. 4, pp. 177–196.
1857b. List of the genera and species of British Diptera, the earlier stages of which are more or less perfectly known, with references to the principal authorities. Nat. Hist. Rev., vols. 3–4, pp. 180–195.
HANDLIRSCH, A.
1883. Beiträge zur Biologie der Diptera. Verh. Zool.-Bot. Ges. Wien, vol. 33, pp. 243–245.
HANDLIRSCH, A.
1908. Die Fossilen Insekten und die Phylogenie der rezenten Formen; ein Handbuch für Paläontologen und Zoologen, 1430 pp., 51 pls.
HANSON, W. J.
1958. A revision of the subgenus *Melanonemotelus* of America north of Mexico. Univ. Kansas Sci. Bull., vol. 38, no. 19, pp. 1351–1391.
HART, C. A.
1895. On the entomology of the Illinois River and adjacent waters, 1. Bull. Illinois St. Lab. Nat. Hist., vol. 4, pp. 247–266.
HERGER, E.
1853. Beitrage zur Naturgeschichte der Insekten: Als Beitrage zur Fauna Oesterreichs: Sitzungsberichte der Kais. Akad. Wiss. Wien, vol. 10, pp. 7–30, 161–178, 460–481.
1856. Neue Metamorphosen einiger Dipteren: Sitzungsberichte der Kais. Akad. Wiss. Wien, vol. 20, pp. 335–350.
1858. Neue Metamorphosen einiger Dipteren: Sitzungsberichte der Kais. Akad. Wiss. Wien, vol. 31, pp. 295–309.
HENNEGUY, F., and BINET, A.
1892. Contribution a l'étude microscopique du systeme nerveux larvaire de *Stratiomys longicornis*. Ann. Soc. Ent. France, vol. 41, pp. 309–316.
HENNIG, W.
1952. Die Larvenformen der Dipteren, pt. 3.
HOWARD, L. O.
1904. The insect book, xxvii+429 pp., 48 col. pls., text-figs.

HOWDEN, H. F.
1955. Descriptions of a new Peruvian *Athyreus* with notes on the method of illustration. Ent. Arb. Mus. G. Frey, vol. 6, no. 2, pp. 667–673.

HRBÁČEK, J.
1945. Notes on the Stratiomyidae of Central Europe. Act. Soc. Ent. Cechosloveniae, vol. 42, pp. 95–100.

HUDSON, G. V.
1951. Fragments of New Zealand entomology, 188 pp.

IRWIN-SMITH, V.
1920. Studies in life histories of Australian Diptera Brachycera, 1: Stratiomyidae, no. 1: *Metoponia rubriceps* Macquart. Proc. Linnaean Soc. New South Wales, vol. 45, pp. 505–530.
1921. Studies in life histories of Australian Diptera Brachycera, 1: Stratiomyidae, no. 2: Further experiments in the rearing of *Metoponia rubriceps*. Proc. Linnaean Soc. New South Wales, vol. 46, pp. 252–255.
1923. Studies in life histories of Australian Diptera Brachycera, 1: Stratiomyidae, no. 3: On the structure of the mouthparts and pharynx of the larval *Metoponia rubriceps*. Proc. Lin. Soc. New South Wales, vol. 46, pp. 425–432.

JAENNICKE, F.
1866. Beitrage zur Kentniss der europaischen Stratiomyiden, Xylophagiden und Coenomyiden, sowie Nachtrag zu den Tabaniden. Berliner Ent. Zeitschr., vol. 10, pp. 217–237.

JAMES, M. T.
1935. The genus *Hermetia* in the United States. Bull. Brooklyn Ent. Soc. vol. 30, pp. 165–170.
1936. Some evolutionary trends in the Stratiomydae. Ann. Ent. Soc. America, vol. 29, pp. 624–626.
1947. The flies that cause myiasis in man. U.S. Dept. Agric. Misc. Publ., vol. 631, pp. 1–175.
1953. An objective aid in determining generic limits. Syst. Zool., vol. 2, no. 3, pp. 136–137.
1957. The larva of *Cyphomyia* and its significance in classification. Ann. Ent. Soc. America, vol. 50, pp. 639–641.
1960. The soldier flies or Stratiomyidae of California. Bull. California Ins. Surv., vol. 6, no. 5, pp. 79–122.
1962. The genus *Dicyphoma* James. Ann. Ent. Soc. America, vol. 55, no. 1, pp. 15–20.

JOHANNSEN, O. A.
1921. *Oxycera tenuicornis* or *Euparyphus tenuicornis*? Ent. Monthly Mag., vol. 57, pp. 140–141.
1922. Stratiomyid larvae and puparia of the northeastern states. Journ. New York Ent. Soc., vol. 30, pp. 14–153.
1935. Aquatic Diptera, 2: Orthorrhapha-Brachycera and Cyclorrhapha. Mem. Cornell Univ. Agric. Exp. Sta., vol. 177, pp. 7–11.

JOHNSON, C. W.
1895. A review of the *Stratiomyia* and *Odontomyia* of North America. Trans. American Ent. Soc., vol. 22, p. 229.
1906. Notes on some dipterous larvae. Psyche, vol. 13, pp. 1–4.

JUSBASCHJANZ, S.
1910. Zur Kenntnis der nach embryonalen Entwickelung der Stratiomyiden. Jenaische Zeitschr. Naturw., vol. 46, pp. 681–736.

KAWALL, J. H. C.
1867. Miscellanea entomologica. Stettiner Ent. Zeit., vol. 28, pp. 117–124.

KILPATRICK, J. W., and SCHOOF, H. F.
1959. Interrelationship of water and *Hermetia illucens* breeding to *Musca domestica* production in human excrement. American Journ. Trop. Med. Hyg., vol. 8, pp. 597–602.

KRAFT, K. J., and COOK, E. F.
1961. A revision of the Pachygasterinae of America north of Mexico. Misc. Publ. Ent. Soc. America, vol. 3, no. 1, pp. 1–24.

KRUPER, F.
1930. Über Verkalkungerscheinungen bei Dipterenlarven und ihrer Ursachen. Arch. Hydrob., vol. 22, pp. 185–220.

KÜNCKEL D'HERCULAIS, J.
1879. Recherches morphologiques et zoologiques sur le systeme nerveux des insectes diptères. Compt. Rend. Acad. Sci. Paris, vol. 89, pp. 491–494.

KUSTER, K. C.
1935. A study of the general biology, morphology of the respiratory system, and respiration of certain aquatic *Stratiomyia* and *Odontomyia* larvae. Pap. Michigan Acad. Sci. Arts Lett., vol. 19, pp. 605–658.
1936. Distributional variation of the ganglionic tracheae in the larva of *Odontomyia cincta*. Pap. Michigan Acad. Sci. Arts Lett., vol. 21, pp. 639–650.

LAXER, A. G.
1880. Larvae of *Stratiomys* in winter. Entomologist, vol. 13, pp. 167–168.

LENZ, F.
1923. Stratiomyiden larven aus Quellen: Ein Beitrag zur Metamorphose der Stratiomyiden. Arch. Naturg., part A, vol. 89, pp. 39–62.
1926. Stratiomyiden larven aus dem Salzwasser. Mitt. Geogr. Ges. Naturh. Mus. Lübeck, vol. 31, no. 2, pp. 170–175.

LEYDIG, F.
1860. Ueber Kalkablagerung in der Haut der Insekten. Arch. Naturg., vol. 26, pp. 157–160.

LINDER, E.
1928. Dr. L. Zürchers Dipteren-Ausbeute aus Paraguay: Stratiomyiden. Arch. Naturg., part A, vol. 92, no. 12, pp. 94–103.
1936–1938. Stratiomyidae. Part. 18 *in* Die Fliegen der Paläarktischen Region, 218 pp.

LUCAS, H.
1879. Larvae of *Stratiomys* sp. living in hot water in Euboea, and very tenacious of life. Bull. Soc. Ent. France, vol. 9, no. 5, pp. 142–143.

LUNDBECK, W.
1907. Diptera danica, genera, and species of flies hitherto found in Denmark, 1: Stratiomyidae, Xylophagidae, Coenomyidae, Tabanidae-Leptidae, Acroceridae, 114 pp.

LYONET, P.
1832. Recherches sur l'anatomie et les métamorphoses de différentes espèces d'insectes, 580 pp. [Posthumous work, published by W. de Haan.]

MALLOCH, J. R.
1915. A revision of the North American Pachygasterinae with unspined scutellum. Ann. Ent. Soc. America, vol. 8, pp. 305–320.

MALLOCH, J. R.
1917. A preliminary classification of the Diptera, exclusive of the Pupipara, based upon larval and pupal characters, with keys to the imagines in certain families. Bull. Illinois St. Lab. Nat. Hist. art. 3, vol. 12, pp. 161–410.

MARKEL, F.
1844. Ueber die larve von *Clitellaria ephippium*. Germar Zeitschr. Ent. vol. 5, pp. 478–480.

MATHUR, R. N.
1933. Notes on the bionomics of *Odontomyia cyanea* Brunetti. Indian Journ. Agric. Sci., vol. 3, pp. 369–376.

MAY, B. M.
1961. The occurrence in New Zealand and the life-history of the soldier fly *Hermetia illucens* (L.). New Zealand Journ. Sci., vol. 4, pp. 55–65.

MCFADDEN, M. W.
1961. An improved technique for using the Berlese funnel. Ent. News, vol. 72, no. 6, pp. 150–152.

MEIJERE, J. C. H. DE
1911. Studien über südostasiatische Dipteren, 6. Tijdschr. Ent., vol. 54, pp. 258–432.
1916. Beiträge zur Kenntnis der Dipterenlarven und -puppen. Zool. Jahrb., vol. 40, pp. 177–322.

MIALL, L. C.
1895. The natural history of aquatic insects, 389 pp.

MIK, J.
1896. Dipterologische Miscellen, 7: Ueber die Fruchtbarkeit von *Stratiomys chamaeleon* Deg. Wiener Ent. Zeit., vol. 15, pp. 106–114.

MÜLLER, G. W.
1925. Kalk in der Haut der Insekten und die Larve von *Sargus cuprarius* L. Zeitschr. Morph. Ökol. Tiere, vol. 3, pp. 542–566.

MYERS
1920. New Zealand Journ. Sci. Techn., vol. 3, no. 2, p. 117.

NEEDHAM, J. G., and BETTEN, G.
1901. Aquatic insects in the Adirondacks. New York St. Mus. Bull., vol. 47, pp. 576–577.

OSTEN SACKEN, C. R.
1882. On Professor Brauer's paper: Versuch einer Characteristik der Gattungen der Notocanthen, 1882. Berliner Ent. Zeitschr., vol. 26, pp. 363–380.

PACKARD, A. S.
1871. The larvae of an unknown *Stratiomys* found in salt water, Clear Lake, California. American Journ. Sci. Arts, vol. 7, no. 3, p. 102.

PEARSON, A. W.
1883. American Nat., vol. 17, p. 1287.

PERRIS, E.
1870. Histoire des insectes du pin maritime, Diptères. Ann. Soc. Ent. France, vol. 10, no. 4, pp. 210–211.

PETERSON, A.
1951. Larvae of insects: An introduction to Nearctic species, part 2, 416 pp.

PLOTNIKOW,
1904. Ueber die Hautung und über einige Elemente der Haut bei den Insekten. Zeitschr. Wiss. Zool., p. 76.

QUIST, J.
1958. A revision and variation analysis of *Euparyphus* and related genera. Unpublished Ph.D. dissertation, Washington State University.

RAFF, J. W.
1931. Notes on *Chiromyza australis* Macq. Victorian Nat., vol. 47, pp. 213–214.

RÉAUMUR, R. A. F. DE
1742. Mémoires pour servir à l'histoire des insectes, 4 vols.

RICARDO, G.
1929. Stratiomyidae, Tabanidae and Asilidae. Fasc. 3 *in* part 6 *of* Insects of Samoa, pp. 109–122.

RICHARDS, A. G.
1951. The integument of arthropods, 411 pp.

RILEY, C. V., and HOWARD, L. O.
1899. *Hermetia muscens*, larva infesting beehives. Insect Life, vol. 1, pp. 353–354.

ROSER, C. L. F. VON
1828. Beitrag zur Naturgeschichte der Insekten Gattung, *Xylophagus* Meig. Naturw. Abh. Würtemberg, vol. 2, p. 188.
1834. Verzeichniss der in Würtemberg verkommenden zweiflüglichen Insekten. Würtemb. Landw. Ver. Stuttgart Corresp., vol. 1, p. 267.

SCHILLING, P. S.
1829. Beiträge zur Entomologie, vol. 1, p. 94.

SCHINER, J. R.
1864. Fauna Austriaca: Die Fliegen, 2 vols.
1863. Diptera. No. 6 *in* vol. 2 *of* Zoologischer Theil *in* Reise der Österreichischen Fregatte Novara um die Erde . . ., vi + 388 pp., 4 pls.

SCHMIDT, R.
1913. Die Salzwasserfauna Westfalens, 70 pp., 6 tables.

SCHOLZ, H.
1848. Ueber den Aufenhalt der Dipteren während ihrer ersten Stände. Ent Ver. Breslau Zeitschr., vol. 2, pp. 1–24.

SCHRANK, F.
1793. Beiträge zur Naturgeschichte von *Stratiomys chamaeleon*. Naturf. Stück, vol. 27, pp. 7–25.

SCHREMMER, P.
1951a. Zur Biologie der Larve von *Hermione* (*Oxycera*) *calceata* und *Hermione* meigeni Staeg: Zugleich ein Beitrag zur Fauna hygropetrica. Österreichische Zool. Zeitschr., vol. 3, pp. 126–139.
1951b. Die Mundteile der Brachycerenlarven und der Kopfbau der Larve von *Stratiomys chamaeleon* L. Österreichische Zool. Zeit., vol. 3, pp. 326–397.

SEGUY, E.
1926. Diptera (Brachycera). Vol. 13 *in* Faune de France, 308 pp.

SPARRMAN, A.
1806. Rön och anmärkningar om Fluge-mask eller Fluge-Larver som inästla sig: lefvande människors innanmäten, jämte aftekningar pa okände species deraf. Svenska Vetensk. Akad. Handl., vol. 27, pp. 239–248.

STEYSKAL, G. C.
1947. A revision of the nearctic species of *Xylomyia* and *Solva* (Diptera: Erinnidae). Pap. Michigan Acad. Sci. Arts Lett., vol. 31, pp. 181–189.

SWAMMERDAM, J.
1737. Biblia naturae, 2 vols. and atlas. [Latin and Dutch in parallel columns.]

TRAGARDH, I.
1914. Skogsentomologiska bidrag, 1–5. Ent. Tidskr., vol. 35, pp. 188–209.

TOWNSEND, C. H. T.
1893. The puparium and pupa of *Subula pallipes* Loew. Ent. News, vol. 4, pp. 163–165.

VAILLANT, F.
1951. Les larves d'*Hermione*. Trav. Lab. Hydrob. Pisci. Grenoble, vols. 43–44, pp. 23–38.
1952. Les larves d'*Hermione* d'Algérie. Bull. Soc. Hist. Nat. Afrique Nord, vol. 43, pp. 8–15.

VAILLANT, F., and DELHOM, M.
1956. Les formes adaptatives de l'appareil bucco-pharyngien chez les larves de Stratiomyidae. Bull. Soc. Hist. Nat. Afrique Nord, vol. 47, pp. 217–250.

VANEY, C.
1900. Note sur les tubes de Malpighi des larves de *Stratiomys*. Bull. Soc. Ent. France, p. 360.

VERRALL, G. H.
1909. Stratiomyidae and succeeding families of the Diptera Brachycera of Great Britain. Vol. 5 *in* British flies, 780 pp.

VIALLANES, H.
1882a. Note sur les terminaisons nerveuses sensitives des insectes. Bull. Sci. Soc. Phil. Paris, vol. 6, no. 7, pp. 94–98.
1882b. Recherches sur l'histologie des insectes, et sur les phènoménes histologiques qui accompagnent le developpement postembryonnaire de ces animaux. Ann. Sci. Nat., vol. 14, pp. 1–348.
1885. Études histologiques et organologiques sur les centres nerveux et les organes des sens des animaux articulés. Troisième mémoire: Le ganglion optique de quelques larves de Diptères (*Musca, Eristalis, Stratiomys*). Ann. Sci. Nat., art. 4, vol. 19, no. 6, pp. 1–34.

VIMMER, A.
1925. Larvy a kukly duojkridleho hmyzu stredoeuropskeho se zulastnim zretelem na skudce rostlin kultur nich.

WALKER, F.
1851. Diptera. Vol. 1 *in* Insecta Britannica.

WESENBERG-LUND, C.
1943. Biologie der Süsswasserinsekten, 655 pp.

WERMAEL, C.
1837. Notice sur la métamorphose d'un xylophage. Bull. Soc. Ent. France, p. 89.
WESTWOOD, J. O.
1840. An introduction to the modern classification of insects, vol. 2.
WHITTEN, J. M.
1959. The tracheal system as a systematic character in larval Diptera. Syst. Zool., vol. 8, no. 3, pp. 130–139.
WILLISTON, S. W.
1908. Manual of North American Diptera, ed. 3, 455 pp.
WIRTH, W. W.
1956. *In* Usinger, Aquatic insects of California, 508 pp.
ZELLER, P. C.
1842. Dipterologische Beiträge. Isis von Oken, vol. 11, pp. 807–847.
ZETTERSTEDT, J. W.
1851. Diptera scandinaviae disposita et descripta, 14 vols.

221-533—66——5

TABLE 1.—*Habitats of stratiomyid larvae occurring in America north of Mexico* (genera arranged by subfamily as given on p. 13)

Genus	Habitat	Reference
Xylomya	Terrestrial; in crotch of tree	New record
Solva	Terrestrial; under bark of trees; in rotted logs	Townsend, 1893; Malloch, 1917; Johannsen, 1922; Greene, 1926; Peterson, 1951; Hennig, 1952
Altermetoponia	Terrestrial; in sod	Irwin-Smith, 1920
Allognosta	Terrestrial; in decaying organic material	Malloch, 1917; Johannsen, 1922
Actina	Terrestrial; in decaying plant and animal material	Fuller, 1934
Beris	Terrestrial; in decaying leaves; under bark of fallen trees; in moss?	Williston, 1908; de Meijere, 1916; Lenz, 1923
Exodontha	Terrestrial; in rotten wood under large rocks	New record
Sargus	Terrestrial; in decaying plant and animal material; in excrement	Westwood, 1840; Lundbeck, 1907; Williston, 1908; Malloch, 1917; Johannsen, 1922; Peterson, 1951; Hennig, 1952
Plecticus	Terrestrial; in decaying organic material	Lindner, 1928; Hennig, 1952
Microchrysa	Terrestrial; in decaying organic material; in garden soil; in excrement	Lundbeck, 1907; Malloch, 1917; Johannsen, 1922; Seguy, 1926; Hennig, 1952
Merosargus	Terrestrial; in debris at base of squirrel's nest	New record
Chloromyia	Terrestrial; in decaying organic material	Brauer, 1883; Cornelius, 1860; Lundbeck, 1907; Seguy, 1926
Cyphomyia	Terrestrial; in decaying plant material	James, 1957
Dicyphoma	Terrestrial; in decaying plant material	James, 1962
Adoxomyia	Terrestrial; in decaying plant material	New record
Hermetia	Terrestrial; in decaying organic material; in excrement	Williston, 1908; Malloch, 1917; Johannsen, 1922; Copello, 1926; James, 1935; James, 1497; James, 1957
Dieuryneura	Terrestrial; in decaying plant material	New record
Oxycera	Aquatic; on margins of lakes, ponds, and streams	Heeger, 1856; Lundbeck, 1907; Johannsen, 1922; Lenz, 1923; Johannsen, 1935; Wesenberg-Lund, 1943

TABLE 1.—Continued

Genus	Habitat	Reference
Euparyphus	Aquatic; on margins of aquatic environments; usually associated with mossy conditions	Johannsen, 1922; Johannsen, 1935; Wesenberg-Lund, 1943; Peterson, 1951; James, 1960
Caloparyphus	Aquatic; in bog or swamp areas; usually associated with mossy conditions	Quist (thesis); James, 1960
Stratiomys	Aquatic; on margins of aquatic environments; usually associated with *Typha* spp.; occasionally in hot springs or saline habitats	Hart, 1895; Johnson, 1895; Miall, 1895; Lundbeck, 1907; Williston, 1908; Malloch, 1917; Johannsen, 1922, 1935; Peterson, 1951; James, 1960b
Hedriodiscus	Aquatic; on margins of lakes and ponds	James, 1960b
Odontomyia	Aquatic; in much the same habitat as given for *Stratiomys*	Hart, 1895; Johson, 1895; Lunbeck, 1907; Williston, 1908; Malloch, 1917; Johannsen, 1922, 1935; Peterson, 1951; James, 1960b
Myxosargus	Aquatic; no specific data available	New record
Nemotelus	Aquatic; under debris at margins of lakes and ponds; frequently in saline habitats	Haliday, 1857a; Lunbeck, 1907; Malloch, 1917; Johannsen, 1922; Lenz, 1923; Johannsen, 1935; Wesenberg-Lund, 1943; Hanson, 1958; James, 1960
Berkshiria	Terrestrial; under bark of trees	Kraft and Cook, 1961; Cook, 1953
Zabrachia	Terrestrial; under bark of coniferous trees	Malloch, 1915; Malloch, 1917; Kraft and Cook, 1961
Neopachygaster	Terrestrial; under bark of trees	Malloch, 1917; Cook, 1953; Kraft and Cook, 1961
Eupachygaster	Terrestrial; under bark of trees	Malloch, 1917; Kraft and Cook, 1961
Pachygaster	Terrestrial; in tree holes; in crotch debris and in hollow trees	Kraft and Cook, 1961

TABLE 2.—*Predators and parasites of stratiomyid larvae in America north of Mexico*

Parasite or predator	Host	Reference
Coleoptera		
Coccinellidae		
Megilla maculata	Egg mass of *Odontomyia* species	Hart, 1895
Hymenoptera		
Pteromalidae		
Rhicnocoelia, new species[1]	*Odontomyia* species	New record
Genus species	*Stratiomys* species	
	Chloromyia formosa	Lundbeck, 1907
Eulophidae		
Tetrastichus species	*Microchrysa polita*	Lundbeck, 1907
Chalcidae		
Chalcis barbara	*Stratiomys norma*	Hart, 1895
Chalcis microgaster	*Odontomyia cincta*; *Odontomyia* species; *Odontomyia vertebrata*; egg mass of *Odontomyia* species	Hart, 1895
Ichneumonidae		
New genus, new species[2]	*Stratiomys* species	New record
Genus, new species	*Nemotelus* species	Lundbeck, 1907
Genus, species	*Sargus* species	Lundbeck, 1907

[1] Taxonomic status as given by B. D. Burks, U.S. National Museum.
[2] Taxonomic status as given by L. H. Walkely, U.S. National Museum.

TABLE 3.—*Ecological and morphological specializations in stratiomyid larvae*

Subfamily	Environment	Nutrition	Mouthparts
Xylomyinae	terrestrial-arboreal	micropantophagous	cylindrical brushes present
Chiromyzinae	terrestrial	phytophagous	brushes and setae absent
Beridinae	terrestrial	micropantophagous	cylindrical brushes present
Sarginae	terrestrial	copraphagous, sapronecrophytophagous	degenerate, cylindrical brushes reduced
Clitellariinae	terrestrial	copraphagous, sapronecrophytophagous	variable, degenerate to well developed
Stratiomyinae	aquatic	micropantophagous	cylindrical brushes absent
Nemotelinae	terrestrial	micropantophagous	cylindrical brushes absent
Pachygastrinae	terrestrial-arboreal	micropantophagous	cylindrical brushes present

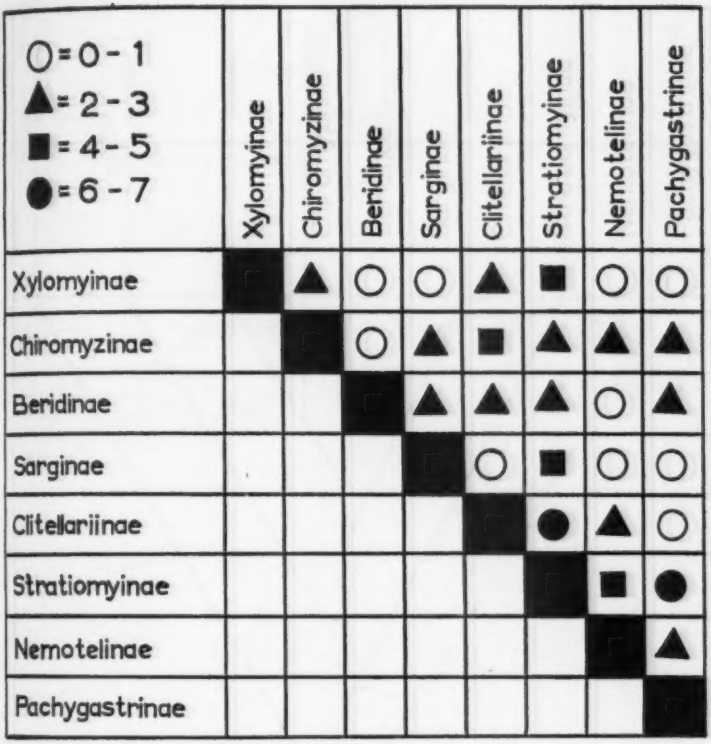


FIGURE 1.—Subfamily relationships of the Stratiomyidae. Each symbol represents a range of numerical value, which is the sum of the differences in 11 characters (25 variates) between a pair of subfamilies. Maximum values indicate maximum differences and distant relationships; minimum values indicate minimum differences and close relationships.

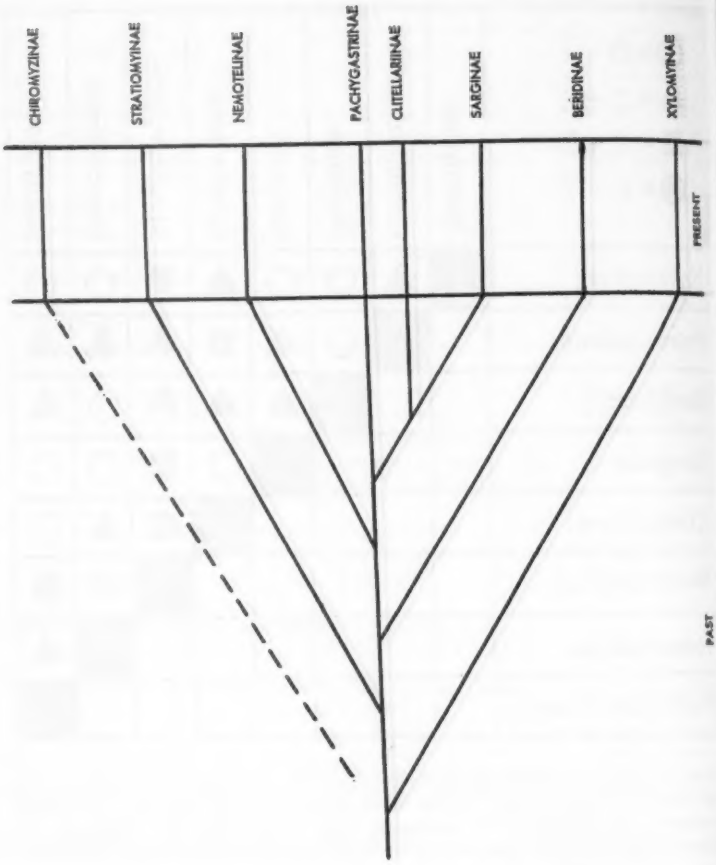
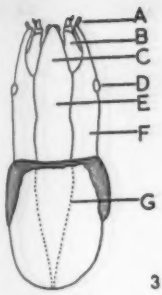
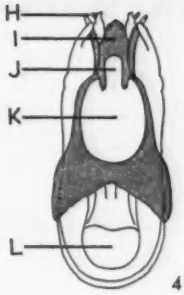
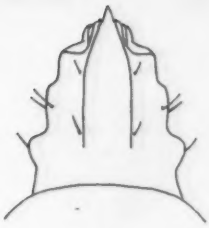
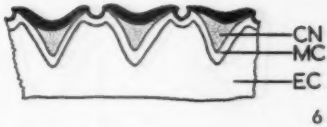


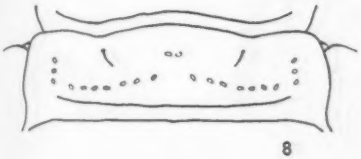
FIGURE 2.—Proposed phylogeny for the eight stratiomyid subfamilies.

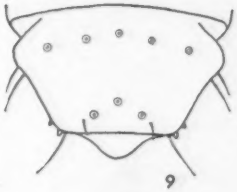


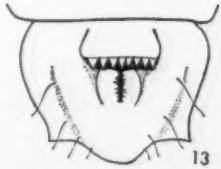




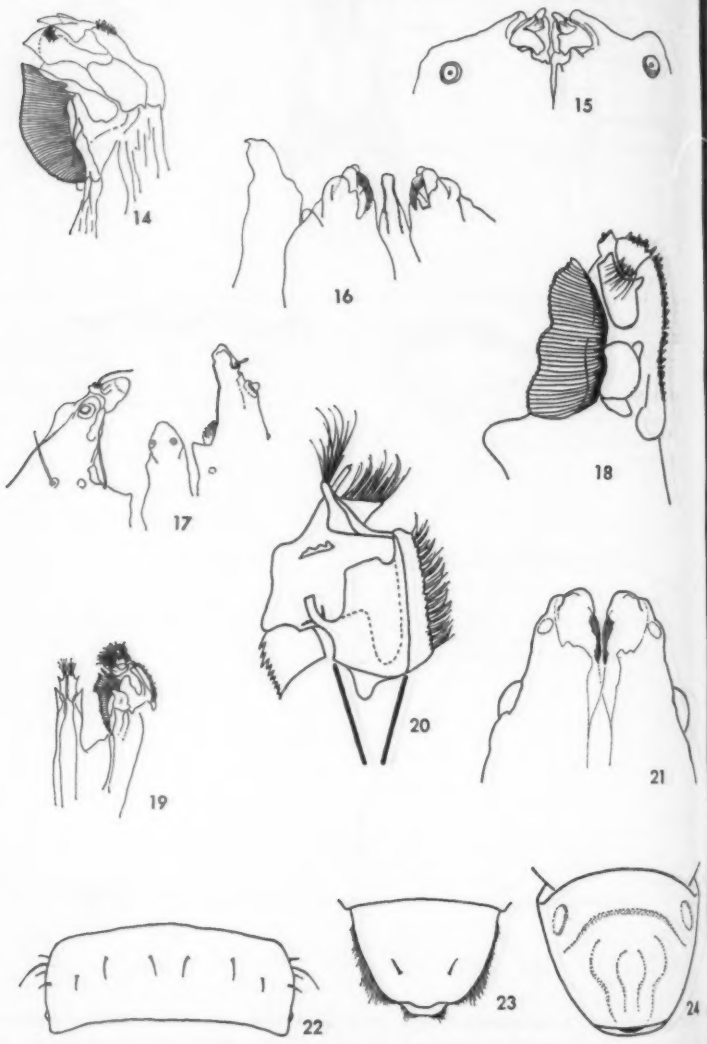




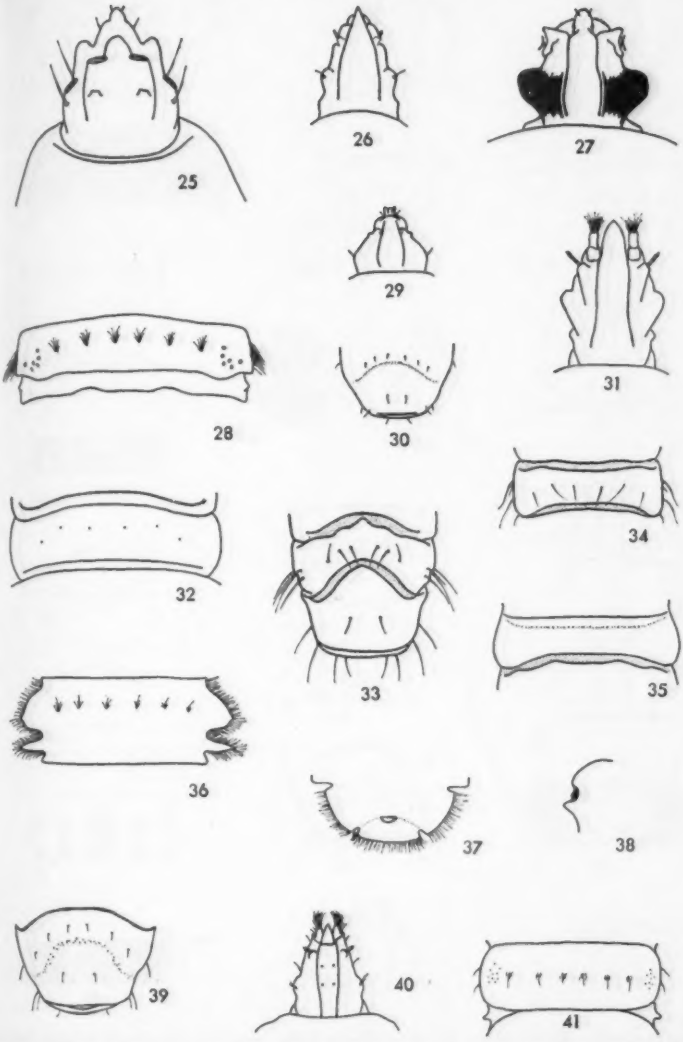




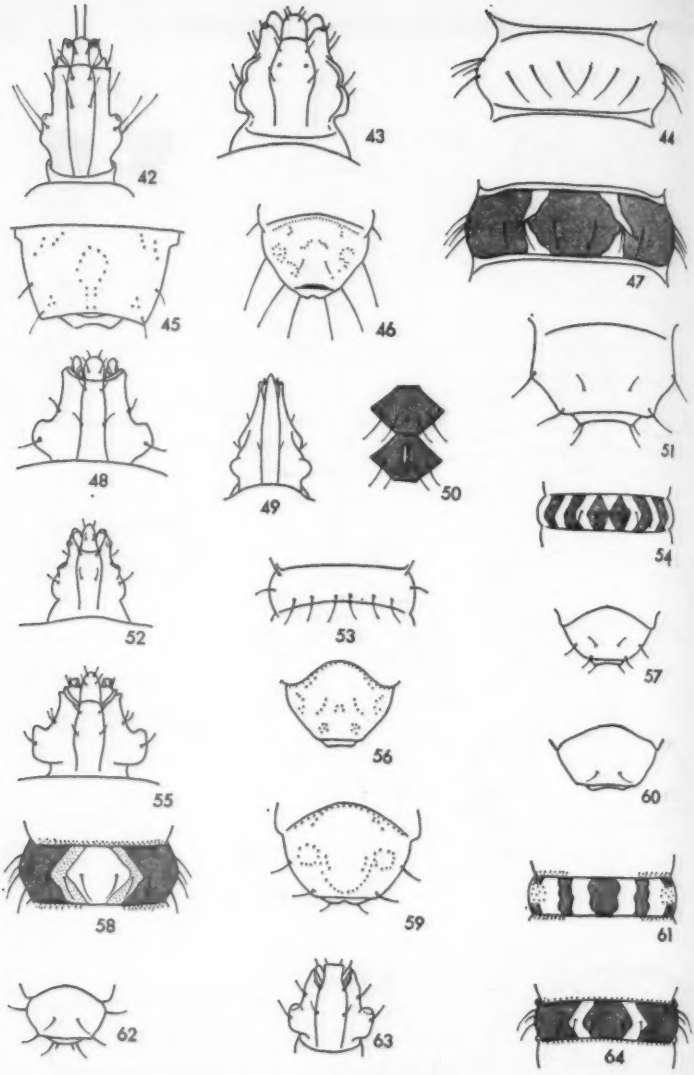
FIGURES 3–13.—3, *Odontomyia* species, head, dorsal view (after Cook, 1949; A=antenna, B=mandibular-maxillary complex, C=labrum, D=eye, E=clypeus, F=ocular lobe, G=frontal suture); 4, *Odontomyia* species, head, ventral view (after Cook, 1949; H=maxillary palp, I=palatum, J=prementum, K=submentum, L=pharynx); 5, *Odontomyia* species, head, lateral view (after Cook, 1949; M=pestle, N=labrum, O=mandibular articulation, P=mandibular-maxillary complex, Q=labium); 6, *Odontomyia* species, integument, cross-section (CN=calcareous nail, MC=mesocuticle, EC=endocuticle); 7, *Xylomya* species, head, dorsal view; 8, *Solva pallipes*, first abdominal segment, dorsal view; 9, *S. pallipes*, apical segment, dorsal view; 10, *S. pallipes*, outline of prothoracic segment, dorsal view; 11, *Xylomya* species, apical segment, dorsal view; 12, *S. pallipes*, head, dorsal view; 13, *S. pallipes*, apical segment, ventral view.



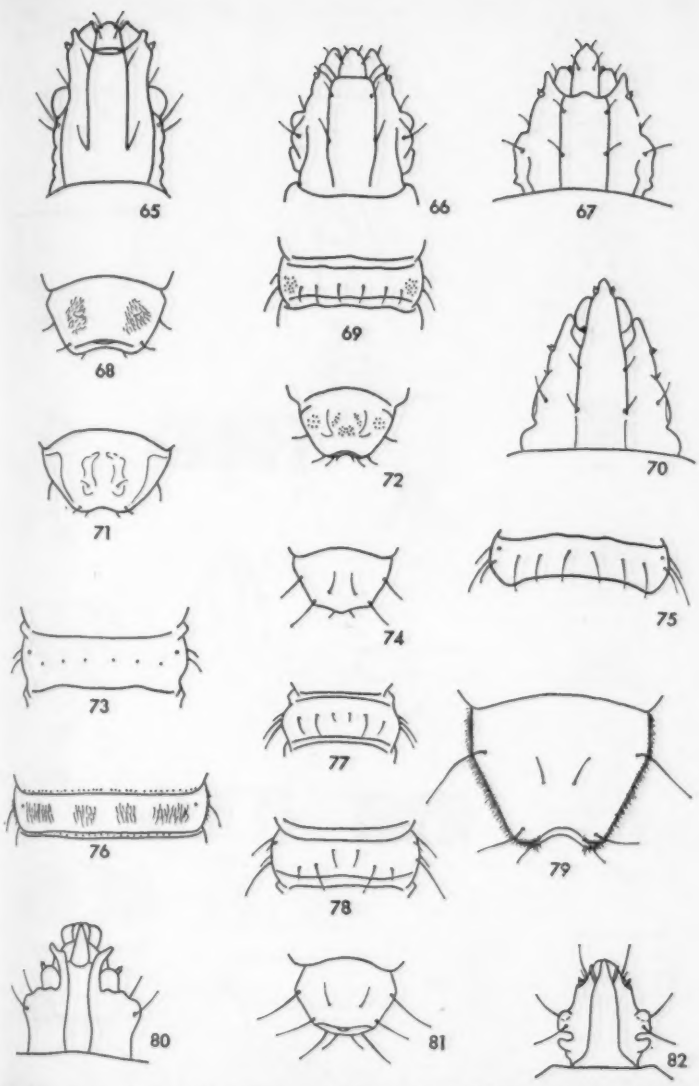
FIGURES 14–24.—Dorsal view: 14, *Solva pallipes*, mandibular-maxillary complex; 15, *Akermeloponia rubriceps*, mouthparts; 16, *Dicuryneura obscura*, mouthparts; 17, *Sargus cuprarius* mouthparts; 18, *Neopachygaster maculicornis*, mandibular-maxillary complex; 19, *Cyphomyia bicarinata*, labium and mandibular-maxillary complex; 20, *Stratiomys norma*, mandibular-maxillary complex (after Malloch, 1917); 21, *Hermetia illucens*, mouthparts (labrum removed); 22, *Xylomya* species, first abdominal segment; 23, *Beris vallata*, apical segment; 24, *D. obscura*, apical segment.



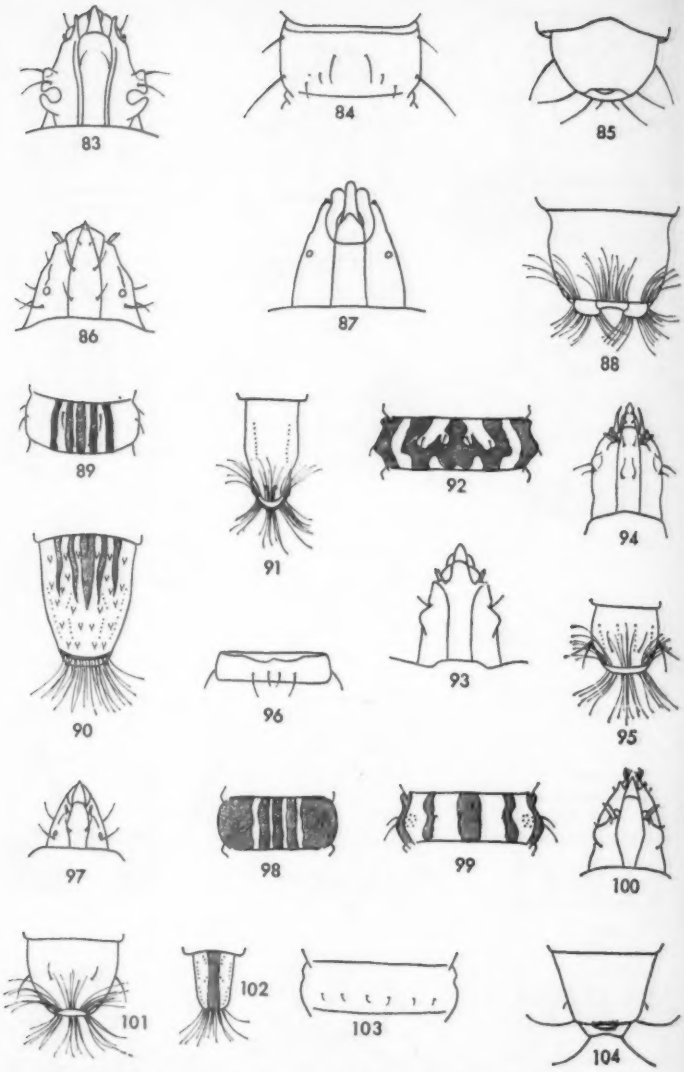
FIGURES 25–41.—Dorsal view: 25, *Allermetoponia rubriceps*, head; 26, *Beris vallata*, head; 27, *Dieuryneura obscura*, head; 28, *B. vallata*, first abdominal segment; 29, *Exodontha lutipes*, head; 30, *E. luteipes*, apical segment; 31, *Allognosta fuscitarsis*, head; 32, *D. obscura*, first abdominal segment; 33, *Allermetoponia rubriceps*, apical segments; 34, *A. rubriceps*, first abdominal segment; 35, *E. luteipes*, first abdominal segment; 36, *A. fuscitarsis*, first abdominal segment; 37, *A. fuscitarsis*, apical segment; 38, *A. fuscitarsis*, outline of prothoracic segment; 39, *D. obscura*, apical segment; 40, *Actina incisuralis*, head; 41, *A. incisuralis*, first abdominal segment.



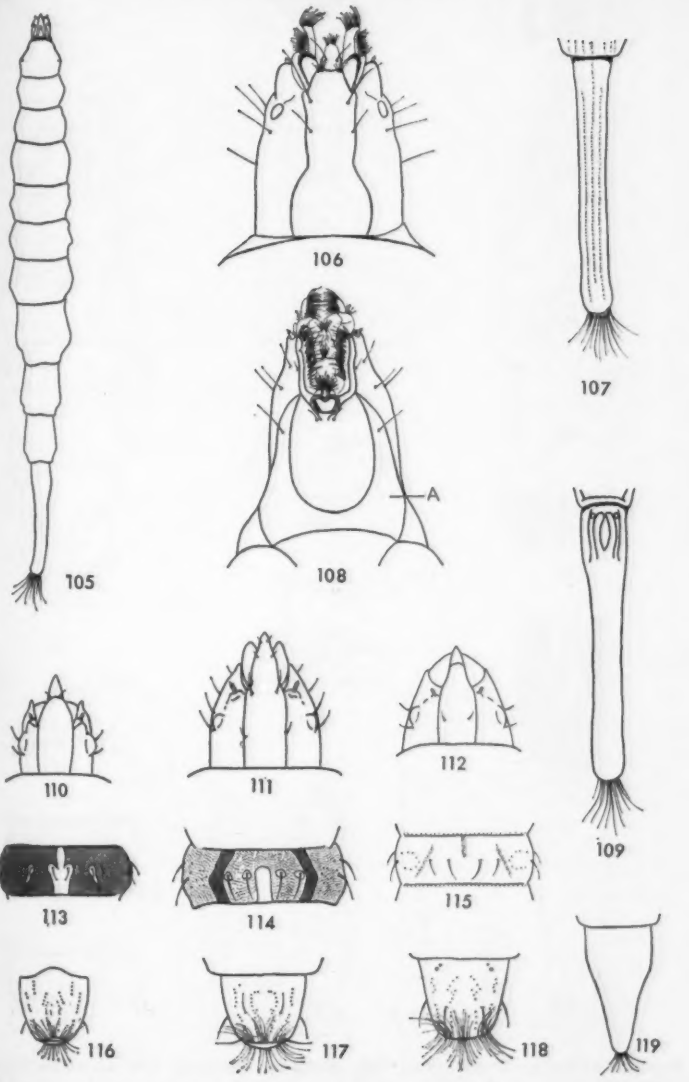
FIGURES 42–64.—Dorsal view: 42, *Microchrysa polita*, head; 43, *Plectieus trivittatus*, head; 44, *M. polita*, first abdominal segment; 45, *Actina incisuralis*, apical segment; 46, *M. polita*, apical segment; 47, *P. trivittatus*, first abdominal segment; 48, *Sargus bipunctatus*, head; 49, *S. lucens*, head; 50, *P. trivittatus*, sixth and seventh abdominal segments (ventral view); 51, *P. trivittatus*, apical segment; 52, *S. elegans*, head; 53, *S. elegans*, first abdominal segment; 54, *S. bipunctatus*, first abdominal segment; 55, *S. decorus*, head 56, *S. lucens*, apical segment; 57, *S. bipunctatus*, apical segment; 58, *S. decorus*, first abdominal segment; 59, *S. decorus*, apical segment; 60, *S. elegans*, apical segment; 61, *S. lucens*, first abdominal segment; 62, *S. cuprarius*, apical segment; 63, *S. cuprarius*, head; 64 *S. cuprarius*, first abdominal segment.



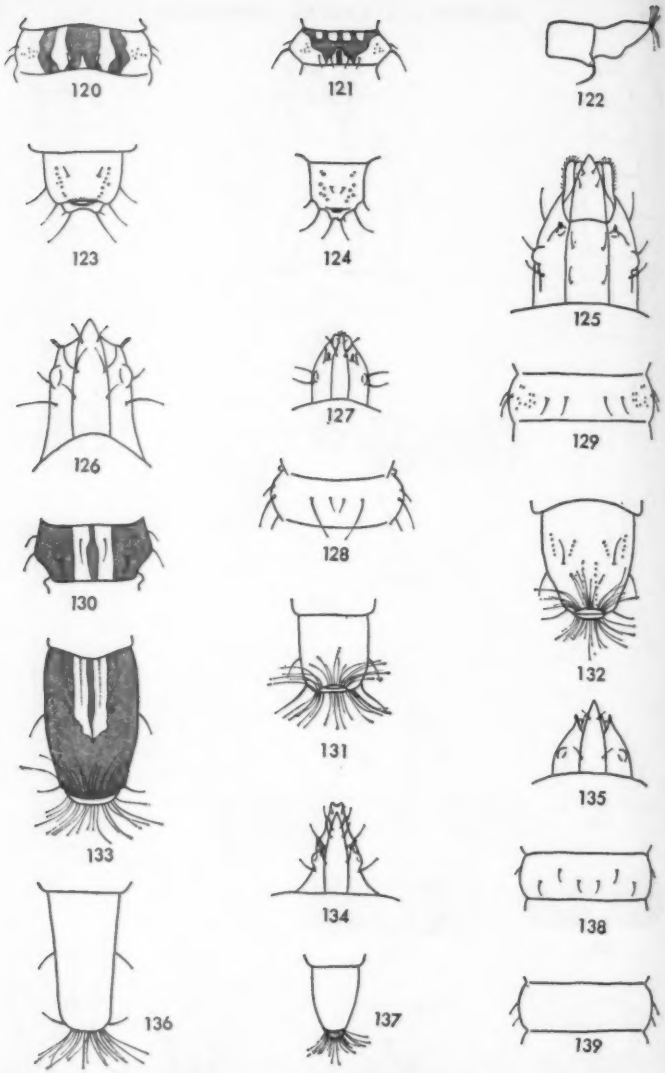
FIGURES 65–82.—Dorsal view: 65, *Hermetia illucens*, head; 66, *H. concinna*, head; 67, *H. aurata*, head; 68, *Hermetia* species, apical segment; 69, *H. concinna*, first abdominal segment; 70, *Hermetia* species, head; 71, *H. aurata*, apical segment; 72, *H. concinna*, apical segment; 73, *H. aurata*, first abdominal segment; 74, *Adoxomyia heminopla*, apical segment; 75, *H. illucens*, first abdominal segment; 76, *Hermetia* species, first abdominal segment; 77, *A. heminopla*, first abdominal segment; 78, *Dicyphoma schaefferi*, first abdominal segment; 79, *H. illucens*, apical segment; 80, *A. heminopla*, head; 81, *D. schaefferi*, apical segment; 82, *D. schaefferi*, head.



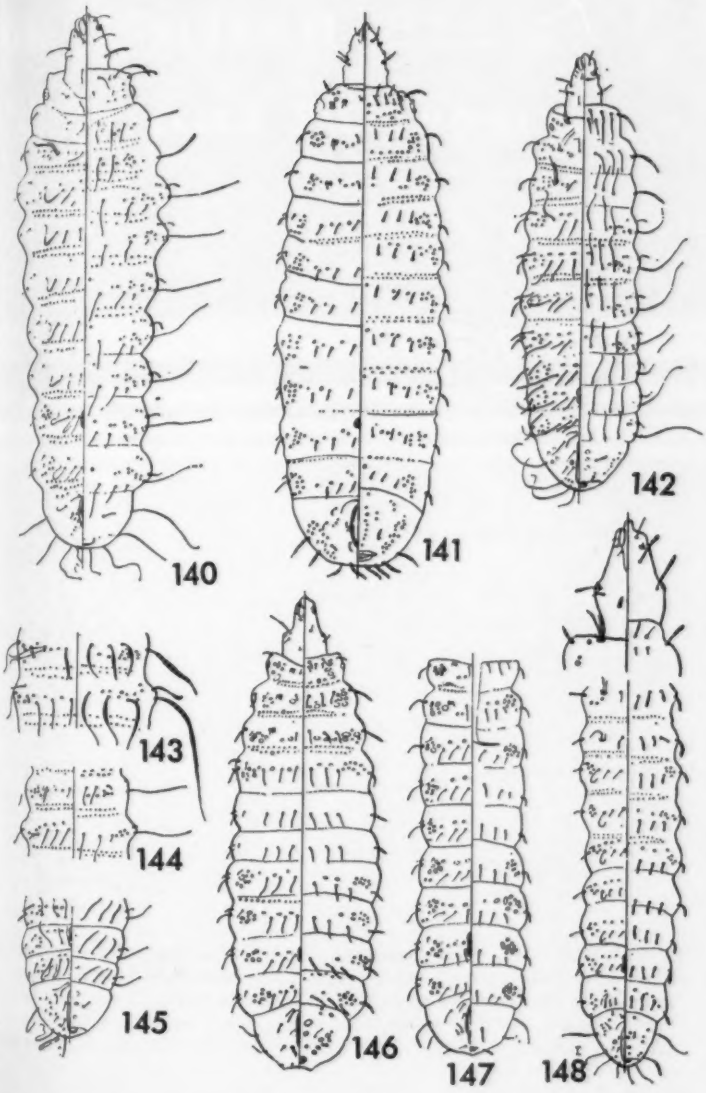
FIGURES 83–104.—Dorsal view: 83, *Cyphomyia pilosissima*, head; 84, *C. pilosissima*, first abdominal segment; 85, *C. pilosissima*, apical segment; 86, *Odontomyia pubescens*, head; 87, *Hedriodiscus vertebratus*, head; 88, *Myxosargus nigricornis*, apical segment; 89, *O. pubescens*, first abdominal segment; 90, *O. pubescens*, apical segment; 91, *H. vertebratus*, apical segment; 92, *M. nigricornis*, first abdominal segment; 93, *M. nigricornis*, head; 94, *Euparyphus limbrocutris*, head; 95, *E. limbrocutris*, apical segment; 96, *Aochletus brevicornis*, first abdominal segment; 97, *A. brevicornis*, head; 98, *O. virgo*, first abdominal segment; 99, *E. limbrocutris*, first abdominal segment; 100, *Nemotelus centralis*, head; 101, *A. brevicornis*, apical segment; 102, *O. virgo*, apical segment; 103, *N. centralis*, first abdominal segment; 104, *N. centralis*, apical segment.



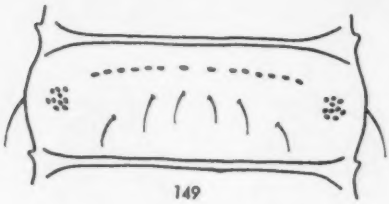
FIGURES 105–119.—Dorsal view: 105, *Stratiomys norma;* 106, *S. norma,* head; 107, *S. norma,* apical segment; 108, *S. norma,* head (ventral view; Abib); 109, *S. norma,* apical segment (ventral view); 110, *Caloparyphus tetraspilus,* head; 111, *C. major,* head; 112, *Caloparyphus* species, head; 113, *C. tetraspilus,* first abdominal segment; 114, *C. major* first abdominal segment; 115, *Caloparyphus* species, first abdominal segment; 116, *C. tetraspilus,* apical segment; 118, *C. major,* apical segment; 118, *Caloparyphus* species, apical segment; 119, *S. discaloides,* apical segment.



FIGURES 120–139.—Dorsal view: 120, *Nemotelus kansensis*, first abdominal segment; 121, *N. canadensis*, first abdominal segment; 122, *Caloparyphus amplus*, ventral hooks (lateral view); 123, *N. kansensis*, apical segment; 124, *N. canadensis*, apical segment; 125, *C. crotchi*, head; 126, *Odontomyia cincta*, head; 127, *C. amplus*, head; 128, *C. amplus*, first abdominal segment; 129, *C. crotchi*, first abdominal segment; 130, *O. cincta*, first abdominal segment; 131, *C. amplus*, apical segment; 132, *C. crotchi*, apical segment; 133, *O. cincta*, apical segment; 134, *N. canadensis*, head; 135, *O. occidentalis*, head; 136, *O. occidentalis*, apical segment; 137, *O. communis*, apical segment; 138, *O. occidentalis*, first abdominal segment; 139, *O. communis*, first abdominal segment.

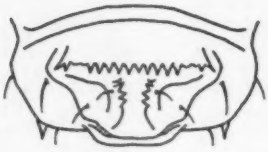


FIGURES 140–148.—140, *Eupachygaster fusca*, dorsal view on right; 141, *Berkshiria albistylum*, dorsal view on right; 142, *Zabrachia plicatum*, dorsal view on right; 143, *E. punctifer*, abdominal terga; 144, *E. henshawi*, abdominal sterna; 145, *Z. politum*, terminal segments; 146, *Neopachygaster maculicornis*, dorsal view on right; 147, *N. occidentalis*, dorsal view on right; 148, *Pachygaster pulchra*, dorsal view on right. (After Kraft and Cook, 1961.)



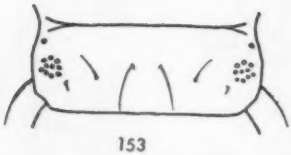
149

151



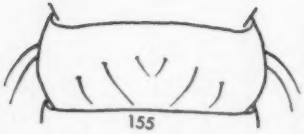
150

152



153

154



155

156

FIGURES 149–156.—149, *Xylomya americana*, first abdominal segment, dorsal view; 150, *X. americana*, apical segment, ventral view; 151, *Merosargus caerulifrons*, apical segment, ventral view; 152, *Cyphomyia marginata*, head, dorsal view; 153, *C. marginata*, first abdominal segment, dorsal view; 154, *C. marginata*, apical segment, ventral view; 155, *Adoxomyia rustica*, first abdominal segment, dorsal view; 156, *A. rustica*, apical segment, ventral view.

U.S. GOVERNMENT PRINTING OFFICE: 1967